JOURNAL OF THE A·I·E·E·

AUGUST 1929

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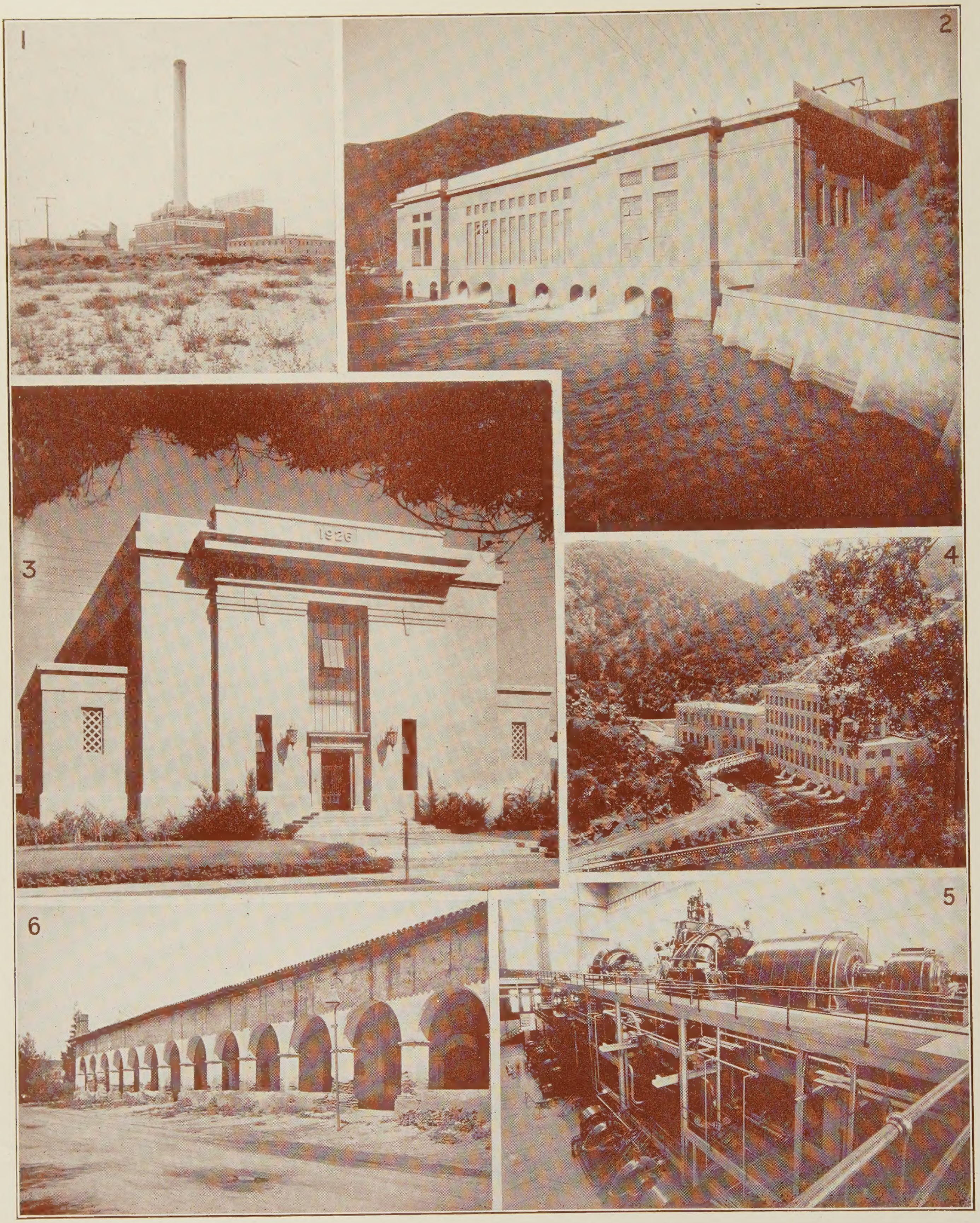
AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
33 WEST 39TH ST· NEW YORK CITY

ACIFIC COAST CONVENTION, SANTA MONICA, SEPT. 3

Pacific Coast Convention—September 3-6

Some Places of Interest near Convention Headquarters



1. Seal Beach Station, Los Angeles Gas & Electric Corporation.
2. San Francisquito Plant No. 1.—Largest of the Hydro Plants Operated by the City of Los Angeles.
3. One of 16 Permanent Distributing Stations of the Department of Water and Power, City of Los Angeles.
4. Big Creek Power Houses Nos. 2 and 2A of the Southern California Edison Company.
5. Generator Room Seal Beach Station, Los Angeles Gas and Electric Corporation.
6. San Fernando Mission, San Fernando, Calif.

JOURNAL

OF THE

American Institute of Electrical Engineers

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS
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(The Journal of the A. I. E. E. is indexed in Industrial Arts Index.)

American Institute of Electrical Engineers

—*Some Activities and Services Open to Members*—

Presentation of Papers.—An important activity of the Institute is the preparation and presentation of papers before meetings of the Institute. Opportunity is offered for any member to present a paper of general interest to engineers at an Institute meeting, or of having shorter contributions published in the JOURNAL without verbal presentation. In preparing a paper for presentation at a meeting, the first step should be to notify the Meetings and Papers Committee about it so that it may be tentatively scheduled. Programs for the meetings are formulated several months in advance, and unless it is known well in advance that a paper is forthcoming, it may be subject to many months delay before it can be assigned to a definite meeting program. Immediately upon notification, the author will receive a pamphlet entitled "Suggestions to Authors" which gives in brief form instructions in regard to Institute requirements in the preparation of manuscripts and illustrations. This pamphlet contains many helpful suggestions and its use may avoid much loss of time in making changes to meet Institute requirements.

Manuscripts should be in triplicate and should be sent to Institute headquarters at least three months in advance of the date of the meeting for which they are intended. They are then submitted first to the members of the technical committee covering the subject of the paper, and if approved will next go to the Meetings and Papers Committee for final disposal. After final acceptance, the paper goes to the Editorial department for printing which requires usually from two to three weeks. Advance copies are desired about ten days prior to the meeting in order to distribute the paper to members desiring to discuss it. Considering the routine through which all papers must pass, the advantage of prompt notification and early submission of manuscripts will be apparent.

Scope of Papers—Institute papers should present information which adds definitely to the theoretical or practical knowledge of electrical engineering and may be derived from activities in any of its branches. Acceptable subject matter is as follows: New theories or new treatments of existing theories; Mathematical solution of electrical engineering problems; Researches, fundamental or practical; Design of equipment, and of electrical engineering projects; Engineering and economic investigations; Operation and tests of electrical equipment or systems; Measurements of electrical quantities; Electrical measurement of non-electrical quantities; Applications of electricity to industrial or social purposes; Education; Standardization; Cooperative engineering organizations; Ethical and social aspects of the profession.

Library Service.—The Engineering Societies Library is the joint property of the four national societies of Civil, Mining, Mechanical, and Electrical Engineers and comprises one of the most complete technical libraries in existence. Arrangements have been made to place the resources of the library at the disposal of Institute members, wherever located. Books are rented for limited periods, bibliographies prepared on request, copies and translations of articles furnished, etc., at charges which merely cover the cost of the service. The Director of the library will gladly give any information requested as to the scope and cost of any desired service. The library is open from 9 a. m. to 10 p. m. every day except holidays and during July and August, when it closes at 5 p. m.

Employment Service.—The employment service is a joint activity administered by the Civil, Mining, Mechanical, and Electrical Engineering societies and is available to the membership of these societies. Branches of this Department are located in Chicago and San Francisco, the main office being located at the societies headquarters in New York. The service is designed to be mutually helpful to engineers seeking employment, and concerns desiring to secure the services of engineers. This department is financed by contributions from the societies maintaining it and from beneficiaries of the service. Further details will be furnished on request to the Managers cf the Employment Service at the main or branch offices, addresses of which will be found elsewhere in this issue.

JOURNAL OF THE A. I. E. E.

DEVOTED TO THE ADVANCEMENT OF THE THEORY AND PRACTISE OF ELECTRICAL ENGINEERING AND THE ALLIED ARTS AND SCIENCES

The Institute is not responsible for the statements and opinions given in the papers and discussions published herein. These are the views of individuals to whom they are credited and are not binding on the membership as a whole.

Vol. XLVIII AUGUST, 1929 Number 8

A Message From the President.

Interrelationship of the Institute and the Individual Member.

AMONG the various objects and functions of the American Institute of Electrical Engineers, the following are definitely stated: "*the advancement of the theory and practise of electrical engineering and the allied arts and sciences, the maintenance of high professional standing among its members and the development of the individual engineer.*"

Founded forty-five years ago, almost as a local organization naturally centering about New York City, where it found membership with which to gather strength for the great future it had undertaken, the Institute nevertheless was small and feeble in its activity and influence, although definite in its ultimate purpose as evidenced by the above statement. During the first fifteen years of its life, when it had not yet attained a total membership of three thousand—less than the membership of each of several of its present districts—it laid much of its present foundation.

As a result of adherence to these three fundamentals, which are here emphasized, the Institute's activity, prestige and personnel have developed until for a long time it has been national in its scope with membership now approaching twenty thousand. In furtherance of these purposes, but few of the many means employed to these ends may be mentioned here: the Transactions, the Journal, sections, branches, national conventions, regional conventions, technical and other committee work, etc., etc. It is believed that the Institute has always been as effective in carrying out these three principles as its resources would permit and has, in general, been notably successful in the accomplishment of the first two.

In recent years, with increasing resources, there has come to be realized with greater understanding the importance of the third element, namely,—"the development of the individual engineer." In recognition of this fact, we have our improved district, section and branch organizations, regional conventions, etc.,—all movements in the direction of carrying the Institute life and support as a national organization to sections or branches within a reasonable radius of the individual wherever he may be located.

The result of this effort on the part of the Institute to go to the individual member is indicated in the annual report of the sections and branches presented at the Summer Convention at Swampscott, which all should read in order to appreciate the scope of this movement.* This line of action must be further emphasized in order fully to achieve its important function in "the development of the individual engineer."

It requires *experience* in the activities of a professional organization for any person to adjust himself to that body so that he can fulfil his obligation to his profession through his contributory endeavor, and, in turn, assure for himself that valuable personal development and benefit which should be his. First, come personal friendship and broader acquaintanceship among his fellows. Second, come that professional contact, breadth of understanding, both human and technical, and recognition which are sure to follow honest effort in these directions. It is for each man to avail himself of, or create, opportunity for such service. He owes it to himself as well as to the Institute.

Harold B. Smith

President

*See "Section and Branch Activities," page 647.

Some Leaders of the A. I. E. E.

Paul Milton Downing, Vice-President in Charge of Electric Construction and Operation for the Pacific Gas & Electric Company, San Francisco, California, and Vice-President of the Institute 1925-1927, was born in Newark, Missouri. He was graduated from grammar school in 1889 and in 1891 had the degree of B. S. conferred upon him by Washington College. Thereafter he entered Stanford University, from which he was graduated with the degrees of A. B. and E. E. in the pioneer class of 1895. During his college career he was active in athletics being one of the football team all four of his college years, and captain of the team in 1894, with Herbert Hoover as treasurer. He was active also on the baseball nine. His interest in the affairs of the University is still keen as President of the Stanford Alumni Association—an office which he has held for three consecutive terms ending with the current year.

After graduating from college, Mr. Downing was employed at first by the Tacoma Light & Power Company, Tacoma, Washington, as dynamo tender; then in 1896 he left this concern to better his position by becoming Assistant Motor Inspector and Powerhouse Operator of the Market Street Railway Company of San Francisco. In 1897 the Blue Lakes Water Company began the operation of the old powerhouse at Blue Lakes City, California, and the promoters offered him the position of Station Superintendent, which he accepted. This was one of the first hydroelectric plants operated in California, and had an installed capacity of 1800 kw., operating at 10,000 volts stepped-up from a generated voltage of 2300.

In 1898 he became associated with John Martin, agent for the Stanley Electric Manufacturing Company, and installed the hydro plant for the Tuolumne Light and Power Company.

In 1900 he became Chief Electrician for the Standard Consolidated Mining Co. at Bodie, California.

On August 15, 1901 he went with the Colusa Gas and Electric Company, for which he installed the electric distribution system, rebuilt the gas works, and managed both branches of the business.

In 1902 he was made Division Superintendent of the Bay Counties Power Company at San Francisco, and in 1903 the Califormia Gas and Electric Corporation and its successor, the Pacific Gas and Electric Company, which was a merger of a number of affiliated companies including the Colusa Gas and Electric Company and the Bay Counties Power Company made him its Superintendent of Substations and Operating Engineer. Later, in 1908, he became Engineer of Operation and Maintenance, and in 1917 was appointed Chief Engineer of the Electric Department.

In 1920 he was made a Vice-President of the company, in charge of electrical operation, and shortly thereafter was given the title of Vice-President in Charge of Electrical Construction and Operation, which is the office he now holds.

In this capacity he had direct charge of the construction of the Pit No. 1 and No. 3 plants, (together with the tunnels and diversion dams), and the Pit No. 4 dam; also the 220-kv-a. transmission tower lines from the Pit Plants to the Vaca-Dixon Substation, one of the first operated at that voltage.

Powerhouse capacity of approximately 285,000 kw. has been installed under his direction, and at the present time he is actively prosecuting work on the 330-ft. high rock-fill dam at Salt Springs on the Mokelumne River, which, when completed, will be the largest structure of its kind in the world. The dam, with the proposed powerhouses, canals, and transmission lines, will involve an expenditure of over $36,000,000.

In addition to the hydroelectric developments of the Pacific Gas and Electric Company, Mr. Downing has charge of the steam-electric stations, and has just completed the installation of a modern high-pressure unit of 37,500 kw., with boilers in Station "C," (Oakland). He is now preparing to install in Station "A," (San Francisco), two 50,000-kw. units with boilers to operate on 1400-lb. pressure. Mr. Downing is also in charge of all the steam heating, water distribution and railway properties of his company.

At the convention of the Pacific Coast Electrical Association, in Pasadena, June 1928, he was elected President of the Association for the ensuing year.

He joined the Institute in 1898 and during 1927 was its Vice-President for the Eighth District.

Mr. Downing is the author of a number of papers relating to the electrical industry. He was appointed to a Conference Committee on Proposed State Legislation on the Supervision of Dams and took an important part in framing the proposed bill for the California State Legislature in 1929.

He is a member of the Permanent Committee of the World's Engineering Congress, of the U. S. Chamber of Commerce, the San Francisco Chamber of Commerce, and of several civic organizations. He is also a member of the San Francisco Industrial Association.

Constructing and equipping of the Harris J. Ryan High-Voltage Laboratory at Stanford University in 1928 at a cost of approximately $400,000.00 was made possible by donations of money and apparatus from the electric power interests of the State; as Chairman of the Committee for interesting the electrical industry and securing donations, Mr. Downing, by personally placing the matter before those whom he thought would be directly or indirectly benefited succeeded in getting a whole-hearted and generous response within a very short time.

Development of Insulating Oils

BY C. E. SKINNER[1]
Fellow. A. I. E. E.

THE integrity of modern transformers and circuit breakers, which are essential features of all transmission systems, is due in no little measure to the insulating oil now universally used in such apparatus. While the oil is a relatively minor part of these devices as a whole, its failure will mean the failure of the apparatus. This is increasingly true as the voltage of the transmission systems is increased. The service rendered by the oil used as an insulating medium in electrical apparatus, is radically different from service rendered by oil in any other class of service and there are rigid requirements for oil for this service which do not exist where oil is used for other purposes. In fact, insulating oil may be considered a material of construction rather than a material of maintenance.

The history of the development of transformer oil begins with the first high-voltage transmission lines in the early '90s, and a continuing and increasing amount of research has been required from that day to this to meet the ever increasing demands for quality and service. The electrical manufacturers' representatives who have been responsible for the quality of the oil used in transformers, have faced many difficulties and have experienced much grief from time to time, due to troubles for which the oil was either directly or indirectly responsible. The fact that such difficulties are rare at the present time does not indicate that further attention to this important material is unnecessary, but on the other hand, it does indicate that a full knowledge of the difficulties which have been so disturbing in the past and a constant watchfulness have mitigated these difficulties to a point where the modern transformer gives perhaps less trouble than any other piece of apparatus in the transmission system.

It may be useful to review some of the history of the development of modern insulating oil and to indicate some of the problems still unsolved, so that a full appreciation by those responsible for the purchase and use of transformer oil may be had. This history may be divided into various chapters, each concerned with the items which seemed to be the cause of the major difficulty prevailing at each particular stage of the development.

When the study was made of oil which might possibly be suitable for the insulating and cooling of the transformers to be used on the Pomona transmission line, this being the first constant high-potential transmission line undertaken in the United States, the study included oils of a very wide variety. Mineral oils, from the heaviest cylinder oil to the equivalent of gasoline and benzine, were carefully studied. Similar tests were made of quite a number of vegetable oils, such as linseed, rosin oil, etc. These early tests were almost entirely on the basis of the determination of dielectric strength. In making these studies, glass containers were used, with the testing electrodes immersed in the oil in a horizontal position. It was observed that any foreign matter visible to the naked eye would line up between the testing electrode and materially reduce the dielectric strength upon the application of the testing voltage, and this at once showed the necessity for extreme care in keeping oil free from foreign matter, such as dirt, fibers, carbonized oil, etc. The necessity for cleanliness has been emphasized again and again with each major increased step in transmission voltages.

In these same tests it was discovered that oil which had been heated in an oven for a considerable period had a much higher dielectric strength than the average oil delivered from the oil manufacturer. There is, of course, the age old tradition that oil and water will not mix, but there seemed no possible explanation for this increased dielectric value of the oil other than that it was due to the elimination of moisture, and that oil was subject to the same difficulties in this regard as most of the other materials of insulation, which at that time had already begun to be studied in considerable detail.

To test the theory, (which from the ancient tradition seemed more or less absurd) that moisture was responsible for the low dielectric value of many oils as delivered, and their changed value on continued heating, the following test was made:

Extremely small amount of water in increasing quantities was added, each addition being a fraction of a drop per gallon of oil, the oil being very thoroughly agitated after each addition. This gave undoubted evidence that very minute amounts of water in the oil would cause radically decreased dielectric strength. This has been checked again and again during the intervening 35 years and more drastic precautions have been found necessary from time to time as the voltage of transformers has been increased. In fact, it has been found necessary to go to the precaution of treating, not only insulation of the transformer to eliminate moisture, but the whole structure, iron-core frame, etc., and to see that the oil which is introduced, especially in transformers for the higher tension is, as we now say, absolutely dry.

The method of drying oil in the early stages of the transformer oil development was accomplished by giving it an extended heating at moderate temperature; but, it was later found that although the temperatures

1. Asst. Director of Engineering, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

Presented at Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., Sept. 3-6, 1929. Printed complete herein.

used were relatively low, sufficient oxidation might be started to affect the endurance of the oil against sludging in service. This lead to an investigation of other methods of drying and cleaning the oil, and this is now accomplished by various filtering and centrifuge processes. The requirement is that all suspended matter and all traces of moisture be removed. This is a difficult matter, due to the fact that while the ordinary refining process results in practical elimination of all free water the final moisture to be removed is apparently in solution in the oil.

In the early construction of transformers, the enclosing cases were frequently made of thin material with deep corrugations and with wooden tops, these wooden tops being used for giving added insulation to the outgoing leads. After experience with a number of disastrous fires with constructions of this kind, the underwriters demanded oil having the highest possible flash and fire test, consistent with satisfactory transformer operation. As a result of this requirement, new studies were made and heavier bodied oils adopted. At the same time, attention was given to a better mechanical structure for the transformer cases. The use of this heavier oil resulted in more sluggish circulation and consequently poorer cooling, and apparently little or no decrease in the fire hazard so far as the oil itself was concerned. Soon after this change was made, a new and unexpected phenomenon appeared and this phenomenon is now generally denominated as sludging. This has been perhaps the most difficult matter to deal with that has arisen in connection with transformer oil.

It was soon discovered that a lighter and more fluid oil was in general less subject to sludging than the heavier oils adopted to minimize the fire hazard; but the adoption of these lighter oils merely minimized and did not cure the sludging trouble. As the units became larger and service more difficult, the sludging trouble increased to a point where transformer manufacturers and users found themselves in more or less continual trouble, and very extended studies were made to determine the cause and cure of sludging.

To date, however, no oil has been found which will not deposit sludge if the conditions of its use are sufficiently severe. By very careful selection and by eternal vigilance on the part of the oil refiners and the transformer manufacturers, oil has been produced which under all modern operating conditions is sufficiently free from sludge to give satisfactory service.

Unfortunately, no test has yet been devised which will quickly determine whether or not oil will be free from sludging in service, although an enormous amount of experimental work has been done and many tests have been proposed and used. This question has been considered of sufficient importance to warrant the cooperation of all the nations interested in the production and use of transformer oil to determine, if possible, a satisfactory sludging test. For this purpose, and working through the International Electrotechnical Commission, duplicate samples of oil have been submitted to laboratories of half a dozen or more countries and extensive tests have been entered into for this purpose. At the meeting of the International Electrotechnical Commission in Bellagio, Italy, in October 1927, the report of the various committees and laboratories which have been working on this question for two or three years, was to the effect that the various tests were conflicting in that one test might indicate that a given oil was satisfactory, while another test just as strongly defended, might indicate this oil to be unsatisfactory.

The result of this meeting showed that additional work must be done in order to determine which of the half dozen methods now more or less used would be the satisfactory one to evaluate oil with regard to its sludging characteristics, or whether an entirely new test must be devised. To date, the only safe procedure which has been found has been that of very careful laboratory tests combined with extended service tests, in many cases of several years, to bring the assurance that oil used would show a minimum of sludging troubles.

In the meantime, the oil refiners and transformer manufacturers, and some of the users of transformers, have been making continual studies, both as to the cause and elimination of sludging troubles, and for the securing of oil that would be free from this trouble and would meet all of the other rigid requirements for transformer oil to be used with the highest voltages.

Through a pure accident, discovery was made fairly early in the study of insulating oil to the effect that free sulphur would very greatly impair its insulating value and much study was given at one time to the effect of both free and combined sulphur in minute quantities in insulating oil. In like manner, the residual acids from the refinery treating and other effects of processing the oil, had to be studied with each change in the refining process to bring about the various characteristics necessary to meet the increasingly exacting requirements on this material.

The manufacturers of apparatus using insulating oils, early found it necessary to establish intimate working relations with the oil refiners and as they were required to meet one requirement after another, the refiners developed a special procedure from the selection of crudes in the fields through the final manufacturing process. The characteristics governing selection at the wells include such items as pour point, freedom from wax, amount of sulphur, etc. In some cases special pipe lines are used to transport the crudes selected for the manufacture of insulating oils to the refineries in order that contamination with other crudes shall not occur. During the preparation of the distillate by the vacuum process, rigid inspection for viscosity, flash, and pour point control is maintained and where these oils require treatment with strong sulphuric acid or equivalent, special care is required to see that there is complete neutralization and thorough washing of the oil, and this treatment is sometimes followed by re-

distillation in order to remove all traces of reaction products remaining after washing.

The advent of outdoor transformer and switching stations imposed an entirely new requirement on transformer and switch oil, namely, the necessity of a very low congealing temperature, or as commonly known, a low-cold test. Transformer oils which were found relatively satisfactory for the old indoor stations had a relatively high-cold test and consequently were not satisfactory for outdoor stations, particularly in cold climates. This requirement for a low congealing temperature is even more rigid in connection with oil switches, which must be free to operate at any temperature which may be reached in the climate where an outdoor switch may be installed.

This requirement for low-cold test oil demanded a whole new series of studies, as the general requirements for indoor apparatus, such as freedom from dirt, moisture, and relative freedom from sludging, etc., had to be maintained. In all such studies it had to be kept in mind that there was a constantly increasing demand for oil and that any oil selected must be available in sufficient quantity to supply this demand. Fortunately, oil has been developed through the cooperation of the oil refiners and transformer manufacturers, which meets the previous requirements, as well or better than any which had been previously used and which has a sufficiently low-cold test to be satisfactory for all ordinary outdoor service.

From almost the beginning of the development of oil for cooling and insulating apparatus, mainly transformer and circuit breakers, the transformer and circuit breaker requirements seemed to be sufficiently divergent so that no single oil would be satisfactory for both services. Certain characteristics of these two services are in opposition to each other, while certain other desirable characteristics coincide. For example, all the early tests and service experience seemed to indicate that the circuit breaker required a relatively heavy and sluggish oil, while the transformer required as light an oil as possible, in order that it might have sufficient fluidity under all conditions to circulate rapidly and transfer the heat from the transformer windings and core to the outer cooling surface. Again, an enormous amount of experimental work was necessary to find an oil which would meet both these services sufficiently well so that utilities would not be required to carry two or three grades of transformer oil and one or more grades of circuit breaker oil. Several years of laboratory and field tests were carried on before there was sufficient confidence on the part of the electrical manufacturers to justify their making a positive assertion that an oil was available in quantity which had all the necessary requirements sufficiently well fulfilled to justify the stand, that this oil could be used as a universal oil for all insulating and cooling work in transformers and circuit breakers.

It has been found that the balance between the two services is very close, and that continued experimental work and the closest possible inspection and testing of oil of this class must be followed in order that the necessary characteristics may be maintained, suitable for all services and for all climates. The advantages of universal oil are so obvious that no arguments are necessary to justify its use.

Throughout the whole history of the development of oil for insulating purposes the question of shipping containers and storage arrangements has been found to be of the utmost importance. In the early days oil was shipped in wooden barrels which were made tight by the use of ordinary glue. This led to interminable trouble from the glue getting into the transformers and other devices, helping to reduce the dielectric strength and to increase the sludging characteristics. Seepage of the oil and the entrance of moisture were common difficulties with such containers.

With the introduction of steel drums, a new kind of trouble developed. Additional dirt and scale was introduced into the oil and it was soon found that the more rigid cleaning and inspection methods did not always eliminate such difficulties. When the use of oil arrived at a point where tank car shipments were necessary, still further difficulties (dirt and water) appeared. It was not at all uncommon in the early days to find a considerable quantity of water in the bottoms of the tank cars containing transformer oil. Condensation of moisture, both on the exposed surfaces of the tank cars and on the surface of the oil itself, were almost inevitable and imperfectly protected openings frequently resulted in additional trouble.

It had been assumed that steel drums with continuous lead washers under the bungs, would be both proof against seepage and proof against entrance of moisture, but this was found not to be the case, and the writer of these notes is familiar with a considerable number of cases where drums of oil, with bung-up exposed to the weather, were found to contain a considerable quantity of water, when it was absolutely certain that these drums were moisture free on shipment. This was apparently brought about by the heating and cooling of the oil due to the changes in temperatures, between day and night, the resulting pressure and vacuum helping the entrance of water at the bung when this would be covered by rain water.

The oil refiner has accomplished, therefore, only a part of his necessary functions when he has prepared the proper grades of oil. These must be so handled after preparation as to deliver them in the cleanest possible condition to the ultimate consumer. Amounts of contamination which would be inconsequential in lubricating oils will cause no end of trouble in transformer oils, so that an entirely new scheme of preparation of packages and lines of special containers have been found necessary. Every container returned to the refiner must be most carefully inspected and put in such condition that it will not cause any of this con-

tamination. The removal of rust and traces of foreign materials which have been stored in the containers, and every other kind of contamination must be absolutely removed, or the container is rejected and many rejections occur in the inspection of such returned containers. The time between the final cleaning and inspection of containers, and the time of filling with the transformer oil and sealing must be an absolute minimum.

Even with all the possible precautions taken, the practise of making individual inspection of oil in drums after allowing a suitable time for foreign matters to collect at the bottom, has been found essential.

There is, of course, involved the shipment of small packages ranging in volume from one to five gallons. Disastrous experiences were run into through the use of ordinary "run of mill" tin cans in the early stages of the business. It later developed that the cause of this was the use of packages, the seams of which had been soldered with acid flux and the latter material had worked into the cans with harmful results to the dielectric strength of the oil which the packages contained. This has resulted in oil refiners installing a special line of machinery for the manufacture of these containers under such control as to insure against the possibility of their becoming contaminated with materials which cause harm to the oil. Not only must these containers be manufactured properly, but they likewise must be tested for leakage and suitably dried before filling, after which they must be immediately capped with the specially designed fittings which have been brought out for this purpose only. Furthermore, it is necessary that inspection be made of a certain portion of the tin containers in order to insure that the quantity of the oil ready for shipment in these packages is running uniformly satisfactory.

During a few months of the year, under carefully controlled conditions, insulating oils of good dielectric strength could be delivered in ordinary tank cars but because of the extreme difficulty of properly drying them before filling, it is unsafe to guarantee deliveries in these tanks at all seasons. As a result of this condition, special cars have been developed with steam coils surrounding the shell, these coils in turn being protected by wooden jackets covered and protected with heat insulating material and thin sheet iron. Only with such equipment as this has it been found possible to properly dry out the cars before filling to such an extent that delivery of dry oil at destination can be assured. With these cars it is possible to not only dry them out before filling is started but during this operation to maintain the temperature of the cars at such a figure as to assure freedom from contamination of moisture in the oil in the cars before the filling is completed and the cars sealed.

A specific example, involving serious difficulty, will be of interest. Serious operating trouble was experienced with some high-voltage circuit breakers, each containing over 3000 gallons of oil. The oil in this particular case was not the standard usually supplied by the manufacturer. As a result of the difficulty the oil had to be completely replaced in an outdoor installation in severe weather, and in the final investigation the trouble was traced to faulty manufacture of the oil and to sloppy methods in its handling.

It was early seen that some sort of cleaning and drying apparatus was essential in connection with the use of oil in some quantity as is required in the average power transmission station. Various schemes of filtering, drying, and cleaning oil have been devised. These included filtering through paper, unslaked lime and the application of heat and various other schemes. The plan which seems to give the best all-round results and is now quite generally used, is that of the use of a centrifuge type of cleaning device, often combined with a pressure filter. Extensive research work in connection with the universal oil referred to above, has shown that both the transformer and switch oil often may be reconditioned after it has become contaminated, to a point where it is unsatisfactory for use. Apparatus for this purpose is now manufactured and very specific instructions have been worked out for the use of this apparatus in reconditioning and for the testing of reconditioned oil.

Parallel to the research work on the oil itself, many improvements have been made in transformer and circuit breaker designs to aid in eliminating the difficulties encountered in connection with the oil problem. It was early proved through research work that exposure of oil to the air very greatly increased its tendency to sludge and that this increase with a given exposure was more or less a function of the temperature of the oil. This led to transformer case designs, which included the conservator type of case and more recently, the inertair scheme, which automatically provides in service for the elimination of both moisture and oxygen from contact with the oil in the transformer. While these devices have not changed the tendency of the oil to sludge under a given set of conditions, they have aided very greatly in changing service conditions, thereby inhibiting sludging and maintaining oil in a clean and dry condition.

The final result of all this work, which has extended over a period of more than 35 years, has been to make the modern transformer and circuit breaker with the universal oil, among the most satisfactory devices which goes into the modern equipment for the production, transmission, and utilization of electrical energy. The transformer and circuit breaker manufacturers, together with the oil producers who have brought about these results, realize that only eternal vigilance and continued research will make it possible to maintain and better the conditions which have been arrived at after so much labor and research in the past.

Population as an Index to Electrical Development

BY N. B. HINSON[1]
Member, A. I. E. E.

IN making plans for the future in the electrical utility business it is necessary to make estimates of future growth. Various methods have been used. The usual method is to plot growth of one kind or another against time. This gives an upward curve which is difficult to project mathematically and usually is misleading if projected ahead more than two or three years in a rapidly growing territory. In the electrical utility field various values have been plotted against the number of consumers or meters. This is all right for past data but for the future the number of meters or consumers would have to be estimated and this would depend upon the increase in population, especially if all the present population now had service.

This led to the use of population as the abscissa rather than time or consumers with any of the values desired as ordinates. This gives a straight line for practically all present values and the future is a straight line projection with a simple formula. The lower end of the line does not usually cross both zero points and this fact gives the changing values per unit of population.

The various values at the very beginning of the industry do not give the correct trend as only a small number of people had service, but the business is now and has been for the last ten or fifteen years developing very uniformly and consistently and these later values give the correct past trend.

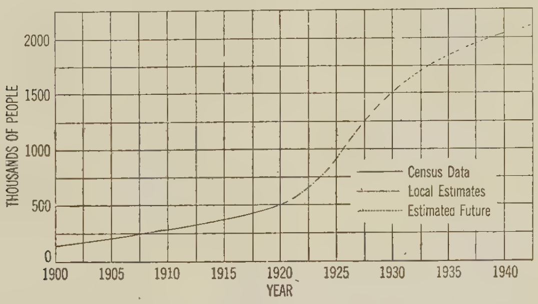

FIG. 1—POPULATION SERVED DIRECT BY SOUTHERN CALIFORNIA EDISON CO.

Population for the past, at least up to the last census date for any city, town, or county, is easy to obtain and in many locations accurate estimates up to 1928 are available. However, when it comes to projecting these values for ten or fifteen years into the future quite a problem arises, particularly in rapidly growing territory such as is found in numerous locations in the United States.

Raymond Pearl in his book, "Studies in Human Biology" has developed a theory of population growth which gives a curve of population for various cities and countries that describes past growth with great precision and fidelity, and predicts future growth in a more satisfactory manner than the usual method of projecting ahead with the same percentage increase as the place under consideration has had for a number

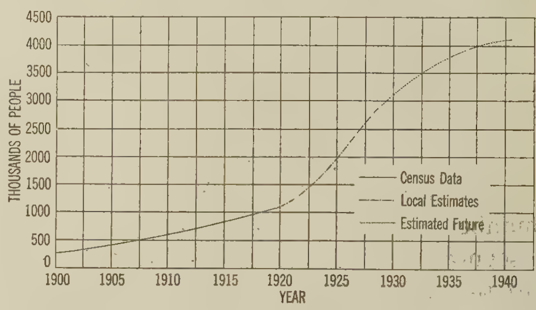

FIG. 2—TOTAL POPULATION SERVED BY SOUTHERN CALIFORNIA EDISON CO.—INCLUDING WHOLESALE

of years back. This type of curve Mr. Pearl calls the "Logistic" type curve though it has come to be known in our territory as the "Fly Curve" from one of the experiments he performed and describes in an article entitled the "Biology of Population Increase."

The population curves used for the territory which will be described were compiled from the census data for 1900, 1910, and 1920, and from estimated values of various Chambers of Commerce, Local and State Officials, Statistical Bureaus, etc., for the years 1921 to 1928. These curves were then projected ahead from the known data, the rate of growth, according to Mr. Pearl's conclusions, decreasing as the saturation point is approached. See Figs. 1 and 2.

The system on which these studies have been made is that of the Southern California Edison Company serving in Central and Southern California. Southern California, in which most of the small towns and cities are located, is one of the fastest growing communities in America. More than 99 per cent of all the houses in the territory covered have electric service and this value has been more than 90 per cent for ten years. Also the Southern California Edison Company supplies 62 per cent of the total kilowatt-hours direct to their own retail consumers, and 38 per cent wholesale to other companies and cities for redistribution and to the railways.

1. Southern California Edison Co., Los Angeles, Calif.

Presented at Pacific Coast Convention of the A. I. E. E., Santa Monica, Calif., September 3-6, 1929. Printed complete herein.

In considering gross revenue, kilowatt-hours generated, and kilowatt peak, the total population in the territory served direct and indirect were used, and for horsepower connected, number of meters, and system betterment budget, the population served direct was used. These are illustrated in Figs. 3 and 4.

As will be seen, the population served is plotted uniformly and the date at which so many people were in the territory, or it is estimated from the population curve will be in the territory, is set opposite that number of people. The values of kilowatt-hours or horsepower or whatever is being plotted are set opposite the year in which they occurred. These points lie in such a position that in all cases a straight line can be drawn through the group, and this line projected ahead gives values for the future.

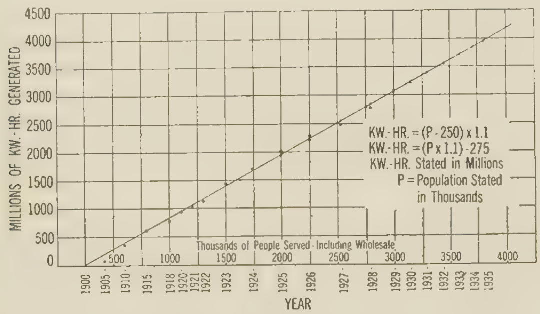

FIG. 3—TOTAL KW-HR. GENERATED YEARLY—UNIFORM POPULATION

Since the values for the future are dependent on population which is an estimation, such future values for more than five years are liable to be in considerable error, but it supplies a means of getting values which can be calculated and is much better than projecting curves which are changing their shape from year to year. Figs. 5 and 6 illustrate the same data plotted against time. This will illustrate the difference in the two methods. Also as additional data are available such as the census for 1930, the population curve may change but it is only necessary to move the date to its correct position on the various studies. In other words, the straight line values are such that they show the value when there is a given number of people, irrespective of the date on which it occurs.

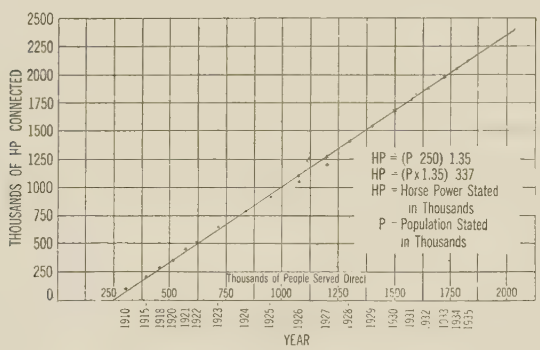

FIG. 4—TOTAL RETAIL HP. CONNECTED—UNIFORM POPULATION

The foregoing are all with regard to the system in general and assist in forecasting so far as generation and transmission are concerned. A study was made of the load on small stations supplying cities and towns so as to be able to forecast the transformer capacity necessary in the future, particularly when new stations are contemplated so as to install transformers that will not have to be changed within a year or two.

These studies were started on a load density basis of kv-a. per square mile. These studies were made on ninety cities and towns in Southern California, ranging from 1500 to 150,000 in population, the average being 10,000. The original study was made in 1925. This same study was made for the year 1928, using seventy cities which are incorporated, and on which it is possible to get a fairly accurate estimate at this time of population.

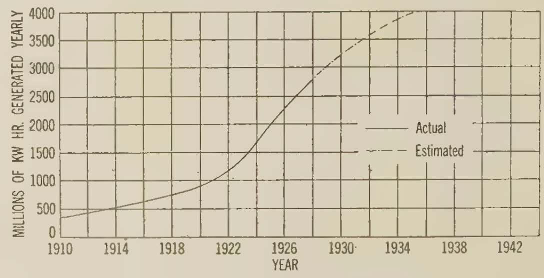

FIG. 5—TOTAL KW-HR. GENERATED YEARLY—UNIFORM TIME

The maximum kv-a. demand for the year 1928 was used and the area in square miles of the developed territory, that is the territory actually built up including all vacant lots. This gave a value of kv-a. demand per square mile which varied from 270 to 2700. There seemed no logical relation between areas so the population for each city was taken and the cities grouped according to size, that is average values for all cities 1000 to 5000, 6000 to 10,000, 11,000 to 21,000, 21,000 to 30,000, 31,000 to 40,000, and 41,000 to 150,000, the last group including only five cities.

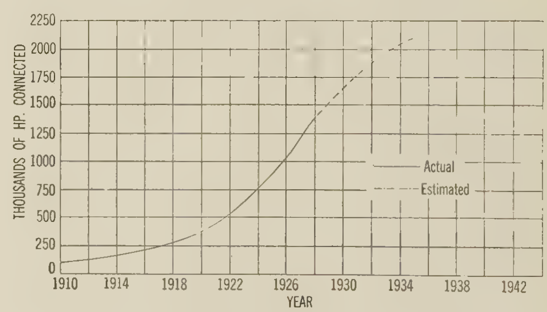

FIG. 6—TOTAL RETAIL HP. CONNECTED—UNIFORM TIME

The values of kv-a. per square mile for each group plotted against the average population for each group gave practically a straight line as shown on Fig. 7. Spotting all seventy of the cities shows how close they follow the average. This gives a simple formula for kv-a. per square mile for various sized cities and this

times the developed area in square miles give the peak demand. This has been applied to several cities for which the data are available for five or ten years in the past and they check very satisfactorily. These apply only to a unit city; if two cities have combined and each had its own business district the combined city will give values of kv-a. per square mile that are too high, that is a city of 25,000 people developed as a unit has a greater load density per square mile than two cities each of 12,500 combined as one city. This system of future peak load projection has been used to set up the probable demand for all cities five years in the future. There has been some increase in the kv-a. demand per square mile during the last three years for any sized city so that it will be necessary to check these data again after the 1930 census. However, it gives a fairly accurate check on the probable future demands.

Fig. 8 shows the peak demand of the various cities plotted against the population. This value has been increasing yearly due to the increased use per capita of electric energy; it was 110 kv-a. per 1000 people in 1920, 125 in 1925, and 150 in 1928. For the smaller cities the peak demand is higher due to less diversity of load. This is also seen in the kv-a. per square mile being lower for the smaller cities as the development is not as uniform as the larger cities.

For making forecasts for the future no hard and fast rules will apply and all these means are used to check from as many angles as possible the future value. The

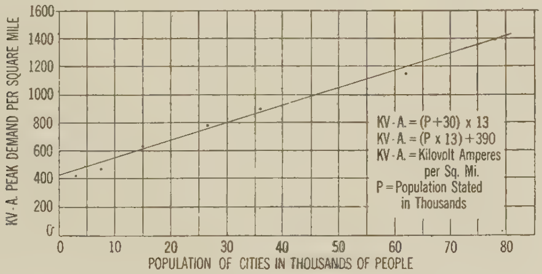

FIG. 7—KV-A. PEAK DEMAND PER SQUARE MILE—GROUP AVERAGES OF 70 CITIES

regular daily and monthly peak load readings on each station which have been kept for a number of years can be projected ahead as a check on future loads.

The distribution system is divided into thirty-two districts with an average of 13,000 customers, the minimum being 3000 and the maximum 50,000. Each of these districts has separate records and is set up similar to a small company. Any data that check up satisfactorily for all the districts may be used for the system. From these data yearly, average values of people per meter, per distribution transformer, per distribution transformer kv-a. rating, per pole, per mile of line, per substation, kv-a. capacity, per substation peak kv-a., per kw-hr. per year consumed can be determined. These values change from year to year but only slightly and these changes can be determined.

These data would not be the same in various parts of the country as the saturation is different and the character of the territory is different. Such values worked out for a particular territory enable fairly accurate estimates to be made of many of the factors entering into its electric utility business. In a territory in which practically every house has electrical service and has had for a period of approximately ten years, the various factors are perhaps more nearly related to the number of people in the city or territory.

This system of using population as a means of determining values of electrical development has been of

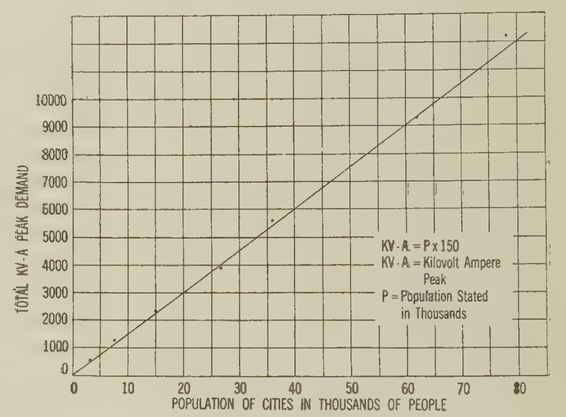

FIG. 8—TOTAL KV-A. PEAK DEMAND OF CITIES—GROUP AVERAGES OF 70 CITIES

great assistance in a rapidly growing territory and has enabled the mathematical determination of values in the future which otherwise would be pure guess work.

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Automatic Stations

ANNUAL REPORT OF COMMITTEE ON AUTOMATIC STATIONS*

To the Board of Directors:

Introduction

This terminates the second year of the existence of this committee. The field of action in which this relatively new committee finds itself is so broad and has so many inviting by-ways that it has been difficult to outline the work. The engineering in connection with the application of automatic control is so fascinating as to result in so many new ideas being steadily developed that the fundamentals are sometimes almost overlooked. It is indeed amazing to realize the changes in ideas which occur in this branch of the industry in a single year. This committee attempts in the following report to outline some of the development and offer suggestions which are intended to benefit this branch of the industry.

Scope

The scope of work of this committee covers automatic and partially automatic generating stations and substations, the committee having complete jurisdiction over all apparatus associated with such stations. In addition the committee has jurisdiction over systems of remote dispatching, control, indications, etc., associated with the industry. The committee is interested in the dissemination of the knowledge and experience already gained in the design and operation of such equipment and combinations thereof, in order that this branch of the industry may be more fully developed.

Economical Construction

The developments of the year indicate a general tendency to take advantage of the economical construction possible with the use of automatic stations. It is still hard to realize the radical difference in station arrangement and set-up between the old firmly rooted manual system of operation and modern automatic operation. We are beginning to see, however, that the presence of a human mind and body in the manual station had a marked effect on station arrangement and that mechanical and electrical things were done solely because of the safety, comfort, and convenience of this human presence. Automatic control has all but eliminated this human body and has moved the mind from the station to the office of the engineer.

It is believed that one of the most radical and economical changes in station arrangement has been the elimination of the continuous switchboard. When this is studied it is found that there is no longer a necessity for assembling all of the control wiring from remote parts of a station at one point at the expense of thousands of feet of wire and conduit just to produce a switchboard assembly that makes a nice appearance.

The above is particularly true in a-c. substations and hydro-station applications where the details of control can and properly should be located as near the equipment controlled as is consistent with good fire protection and safety. It is now becoming common to see control panels located in various places throughout a station close to the equipment controlled, thus saving considerable in wire, conduit, and hazard.

Another saving has been realized from the reduction in size and in some cases the complete elimination of heating plants.

Ventilation has also been reduced, as in many cases a considerable amount of air was required over and above that actually required by the station apparatus for the comfort of the operating employes.

The problem of station location has been eased somewhat by the advent of automatic control as stations can now be located in places where it would be almost impossible to keep operating men on the job on account of the absence of what might be considered the proper amount of daylight, pure air, water, etc., necessary for the continuous maintenance of human beings.

Research and Development

Research during the past year has brought forward many improvements in detail apparatus which are contributing much to simplify the problems of application. Careful analysis of operating records disclosed the need of more simple means for the adjustment of

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L. D. Bale,	Joseph Hellenthal,	Roy M. Stanley,
C. A. Butcher,	Chester Lichtenberg,	L. J. Turley,
M. S. Coover,	S. J. Lisberger,	F. Zogbaum.
	G. H. Middlemiss,	

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Prtnted complete except bibliography.

equipment to meet a wide range of applications, particularly for the calibration of relays. Much has been done in this connection with the result that not only have improvements in relays simplified matters of calibration but by extending the range of application, the number of types of relays required has been reduced, thus greatly simplifying routine inspection and maintenance.

Simplified and improved supervisory control and remote metering systems have been produced as a result of experience with several very successful schemes in numerous applications.

Some work has been done in the development of devices for recording operations, quantities, etc., on charts, but this appears to be one of the weakest points in automatic development. There are devices available for recording almost anything desired but either they are insufficiently reliable or their cost is prohibitive for extensive applications.

Simplified schemes of control for the automatic switching of rotating apparatus looking toward reduction in the number of moving parts are being tried out. The economics of application are being given a great deal of study. On a number of metropolitan street railway properties, the items of power consumption from the generating stations to the car wheels are being carefully analyzed. Operating voltages best suited to given operating areas will be selected and means for automatically or remotely controlling the substation apparatus for proper adjustment of the voltage to operating conditions will be provided.

Operators and careful analysis of operating results are the sources of information which will enable the manufacturers to develop new and improved equipment and to this end, it is urged that systematic and well-kept records be made available on operation, inspection, and maintenance. Well operated stations are the proving grounds and as essential to progress as the laboratory.

Operating Reports and Inspection

The predecessors of this committee have stated that the art would advance much more rapidly if more operating engineers would avail themselves of the opportunity at Institute meetings to tell of their individual experiences, through papers and taking part freely in discussion. Your present committee wishes to emphasize this and add an invitation to correspond freely with the members of this committee on subjects of interest to the followers of the automatic art. It is felt that in this way the annual reports of this committee will be made more representative. With this idea in mind your committee has this year sent out questionnaires attempting to gather operating, maintenance, and inspection data from a wide field of experience, covering a variety of applications. While these questionnaires may be considered a burden by some, this committee feels that a great many engineers are vitally interested in the subject and are willing to furnish the data requested to the end that the art may be more universally applied and incidentally improved. Some answers to the questionnaire have been received but not sufficient to present a recapitulation in the pages of this report. This committee intends to turn this partly finished work over to its successors with the earnest recommendation that they carry it forward.

Inspection and maintenance of automatic plants may be catalogued into two general classifications, equality and quantity, depending entirely upon the continuity of service expected and demanded of the automatic plants, and by the individual managements.

The word "maintenance" is used advisedly in view of the fact that inspection and maintenance are so closely allied at times as to be almost inseparable.

The old phrase, "getting out of a thing what you put into it" is exemplified in automatic station operation. However, the curve of failures of equipment to function plotted against dollars spent on inspection and maintenance, is not at all uniform, cost ratio increasing much more rapidly as the number of failures declines to the zero point. This point is clearly illustrated by a member of the subcommittee, and a pioneer in the automatic operation of a large metropolitan system, who states that two extremes are possible in automatic substation operation, under inspection and maintenance, and over inspection and maintenance.

A plant may be used for such a test, little or no inspection and maintenance being given during a predetermined period of time, observing the number of failures occurring, with their causes. By taking this number of failures as the unit, one hundred for example, and increasing inspection and maintenance, the failures will diminish rapidly to a point whereby 90 per cent of the one hundred will have been eliminated during an equal time period. At this point, inspection and maintenance can be doubled with the resulting effect of the elimination of only a few of the remaining ten failures. A happy medium between the two extremes is therefore logically assumed the most economical method of operation.

Past and present experience as reported by the various operating engineers, seems to disclose the fact that to function properly, automatic equipment should be given casual and periodical inspections. These inspections vary according to the needs and conditions of the individual installation, and the severity of service. The casual inspections on metropolitan systems as reported, are made as often as two hours apart during the heavy hours of the day, and two or three days apart on other systems and conditions.

These inspections usually consist in observing the functioning of equipment in service, overheated contacts, graphic chart clocks for time, inking, bearings, overheating, ventilation, etc. For stations outside of metropolitan districts, the casual inspections are likewise reported as being made daily on some systems, and weekly on others, ranging in the average of two or three

times a week, with a tendency to make fewer inspections when the stations are equipped with supervisory control. The actual time required to make a casual inspection is much less than the traveling time.

A startling fact was disclosed when only about half of the 23 engineers replying to the questionnaire indicated that they followed any prepared method in inspection and testing but relied upon the field man entirely. It followed that in these cases no form was provided on which the field man could accurately report. Results from such a method must surely vary with the character and temperament of the inspector and cannot possibly be conducive to good operating and service results. Many of the replies, however, indicated the existence of very closely prescribed test and inspection methods along with very complete records including very comprehensive classifications of device failures. That sort of practise, if universal, would most certainly pay dividends to the industry. This year's committee has become so intensely interested in this subject that the thought has occurred to attempt the standardization of test and inspection methods, forms, and failure classifications. It is felt that with standard forms in use this committee could be made a clearing house for much valuable information, thus permitting the designing engineers to profit by the mistakes of others as well as by their own.

In order to implant the thought we are herewith submitting a suggested form.

STANDARD AUTOMATIC SUBSTATION TROUBLE FORM

Date..................19.....

..............................Station No.............

Device Which Failed..

....

Machine, Transformer or Circuit Number..

....

Nature of Failure..

....

Cause of Failure...

....

Consequences..

....

How Remedied..

....

Located By:..Repaired By:..........................

Unit Out of Service from................M.................To................M.................

What Load Actually Interrupted and for How Long..........................

....

What Load Otherwise Affected and for How Long..........................

....

Copies to:

√ CLASSIFICATION ....
☐ Improper Adjustment by Mfg. ....
☐ Improper Adjustment by Owner. ....
☐ Improper Application.
☐ Improper Assembly Approvals:
☐ Improper Design. ....
☐ Lack of Proper Inspection by Owner. ....
☐ Defective Workmanship by Owner.
☐ Defective Workmanship by Mfg.
☐ Unforeseen Operating Conditions.
☐ Undetermined.

....

By the use of forms similar to the one herewith submitted, several operating companies have been able to detect particular devices, schemes of connection, etc., which persistently give trouble, and as a result have increased the reliability of their equipment to a considerable degree by correcting the troublesome elements. One company in addition to the classification of the failures shown on the form, classifies and records the failures under device numbers and types.

One of the companies sends copies of all trouble forms to the manufacturer of the equipment involved, thereby giving the manufacturer the opportunity to turn the experience into something profitable to both themselves and the user.

Papers

Six papers were presented to the Institute during the year on the general subject of automatic stations and were sponsored by this committee:

Automatic Mercury Arc Power Rectifier Substation on the Los Angeles Railway, by L. J. Turley, Spokane, Aug. 1928.

The Automatic Substation—Its Relation to Electric Distribution Systems, by S. J. Lisberger, Spokane, Aug. 1928.

Telemetering, by Linder, Stewart, Rex, and Fitzgerald, New York, Jan. 1928.

Automatic Mercury Rectifier Substations in Chicago, by A. M. Garrett, Cincinnati, Mar. 1929.

Automatic Reclosing of High-Voltage Circuits, by Robertson and Spurgeon, Dallas, May 1929.

Automatic Transformer Stations of Edison Electric Illuminating Co. of Boston, by W. W. Edson, Swampscott, June 1929.

Standards

Standards for automatic stations (No. 26) were adopted and issued in 1928. It was realized that in view of the rapid progress of this branch of the industry it would be necessary to revise these standards from time to time. A subcommittee has worked out some desirable changes which are not voluminous enough to warrant a revision of the Standards as published. However, this committee will add to this group of changes from time to time, until it is felt that it is worth while to present them to the Standards Committee with recommendations.

Bibliography

With the idea that a complete bibliography of automatic station literature would be of inestimable value to the electrical engineer, this committee published as an appendix to its report last year a complete bibliography up to the date of the report. A supplement covering literature published from the last report to March 1, 1929, is included in the complete report as an appendix. Acknowledgment with thanks is hereby given to the Main Library, General Electric Company, for this service.

"Synchronized at the Load"

A Symposium on New York City 60-Cycle Power System Connections

I. A Fundamental Plan of Power Supply
By A. H. KEHOE

II. Calculations of Systems Performance
By S. B. GRISCOM

III. System Tests and Operating Connections
By H. R. SEARING AND G. R. MILNE

Review of the Subject

Under our modern conditions it has become a common experience to have certain improvements adopted as necessities, although at some earlier time they would have been classed as extreme luxuries. Electrical service rendered by metropolitan public utility companies in recent years has evolved into one of these necessities due to the change in customs and in living conditions of the American people. In the initial stages of development, while the central station industry was taking the preliminary steps to establish itself in the commercial field, its product being expensive was purchased only where it could be indulged in as a luxury. During this period, methods of utilization of electrical service were very limited, being confined almost entirely to illumination. Such electric systems as existed were small, and the problem of their continuity was not of major importance. Disturbance and even interruption to customers' supply was a regrettable but not a vital incident. Cost of energy was the principal consideration rather than the reliability of supply, particularly where strong competition with other established forms of service was to be expected. As the art developed, many efforts were made to improve the quality of service in order to make a more salable product; nevertheless some interruptions were still experienced and were usually considered a necessary evil. With a much improved, but less expensive product, other competing methods of supply gradually became obsolete, leaving the central station alone in its field with an obligation to render the best possible service. Then interruptions could no longer be considered minor incidents.

Service to districts with high-load density, such as the central portion of cities, very soon felt the effect of this requirement, and the demand was usually met by adopting systems of distribution which would give reliable service although at increased expense over other methods of supply, which, while much less costly, could not offer the same degree of reliability. The influence of quality service had its effect on the requirements of these as well as other districts, and the entire elimination of service interruptions has everywhere been given the most serious consideration due to the dependence of the customer on a reliable service that will not cause interruptions resulting in serious inconvenience, economic loss, or possible hazard to life. Also there are many new types of utilization that are constantly being adopted as higher reliability with lower costs makes these available to all. With further reduction in costs, many other new applications are certain to arise. Thus, it follows that low-cost reliable service produces greater utilization which, in turn, makes it imperative to render still better service. This characteristic development is a feature of American life, and its counterpart in some form of material progress will be found to be the basis for most of the changes which have taken place in our modern customs. In the case of metropolitan central station companies, the huge concentrations of power required to provide the services which are a necessity for the normal life and business of the community, make the problem of reliability of supply at low system costs of vital importance to all.

The papers comprising this symposium present a new principle of decentralization of power sources and cover the investigation of a new plan of design and operation of a metropolitan power system. This arrangement is expected to provide the solution to the problem of reliability of supply and low system costs. The underlying ideas have been verified not only by experiments on one system but also by an extensive engineering analysis. Close agreement was observed between calculated and test results, and this should justify the use of the analytical methods outlined in applying the principles involved to the design of other power systems. The fundamental plan is described and the methods and results of calculations made are given. The symposium concludes with system tests and operating experience with the new arrangement of connections.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929.

"Synchronized at the Load"—I

A Fundamental Plan of Power Supply

BY A. H. KEHOE[1]

Fellow, A. I. E. E.

Synopsis.—The New York 60-cycle system is operating with connections giving parallel paths between generating units only at the load. High values of reactance result for synchronizing circuits between the several generating units, but the usual values are present in the main energy channels between generators and load. Connections are contrasted with two common types of metropolitan power systems; i. e., the "close linked" and "loose linked" systems, and are shown supplemental to multiple-feed network distribution, as the principle of using separate multiple feeds from independent generators connected in parallel only at the load extends the network distribution system to the generating stations. In completely networked distribution, the 120/208-volt mains acting as a short-circuit-proof bus, supply the only synchronizing paths between generators. Substation busses serving radial load are substituted where complete networks do not exist. Calculations, tests, and operating experience indicate synchronizing power sufficient to give stability to all elements of the system not directly affected by a fault. Some advantages derived are: Increased reliability of generating sources, lower interrupting duties on circuit breakers, and reduction in service voltage disturbance.

Connections for Improved System Behavior

THE New York City 60-cycle power system is now operating with an arrangement of connection which gives paralleling paths between generating units only at the load. Each generator while in service on this system is described as being "synchronized at the load." This term refers to the conditions under which each unit is maintained in synchronism, but it does not refer necessarily to the initial synchronizing of one generator with the rest of the system. Fig. 1 shows a simplified diagram of the arrangement. Such a scheme of connections gives high reactance values for the synchronizing power circuits between the several generating units in comparison to the values which are in general use with generators also synchronized at the station bus. Nevertheless, the main energy channels between generators and the load have reactances, in respect to normal capacity, of the same order as those usually experienced with metropolitan underground cable systems. Thus, while this arrangement does not fundamentally affect the normal power distributing characteristics of the system, it does improve system behavior during abnormal conditions in several ways which are discussed in this and in companion papers.[2]

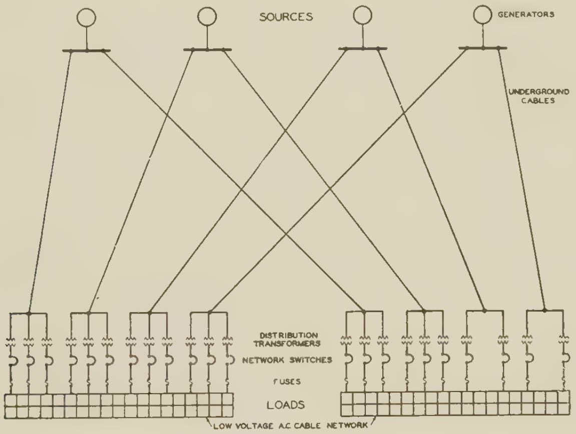

Fig. 1—Schematic Connections for System Synchronized at the Load

Typical Power System Arrangements

Ever since d-c. machines were first operated in parallel, or following this when individual drive alternators were first synchronized, the usual arrangement has been to provide for paralleling as near to the sources of power as possible. For a number of years, machine capacities and system reliability have required some means of obtaining increased reactance values to limit fault currents, and many large station busses have been broken up into sections by inserting current-limiting reactors. Generator leads supplying the bus and feeders from the bus in some cases have been similarly equipped. Such busses usually take the form of a closed loop or ring and are composed of a number of sections, each connected to its adjacent sections through reactances. Another scheme in use is the star arrangement, in which each individual bus section is connected through a reactor to one common bus or star point. Since the amount of reactance as well as its location in the circuit can easily be varied, many different plans of bus layout are in use. In general, however, it has become standard practise to parallel generators in a generating station as close to the source as possible by using some plan of either the "ring" or "star" bus arrangement.

Whenever systems are supplied from more than one generating station, it is customary to use either tie feeders between stations to provide an extension of the paralleling bus, or the system is divided into districts which are normally tied together with relatively low-capacity ties between each district to maintain the system in synchronism as an aid to operation under

1. Electrical Engineer, The United Electric Light and Power Co., New York, N. Y.

Printed complete herein.

2. *Calculations of System Performance* by S. B. Griscom.

System Tests and Operating Connections, by H. R. Searing and G. R. Milne.

normal conditions. With the first mentioned arrangement (Fig. 2), that is, with tie feeders between generating stations, the capacity in several stations is used to supply a wide area. Therefore, it is essential that synchronism be maintained not only between all units in one station but also between all stations. This

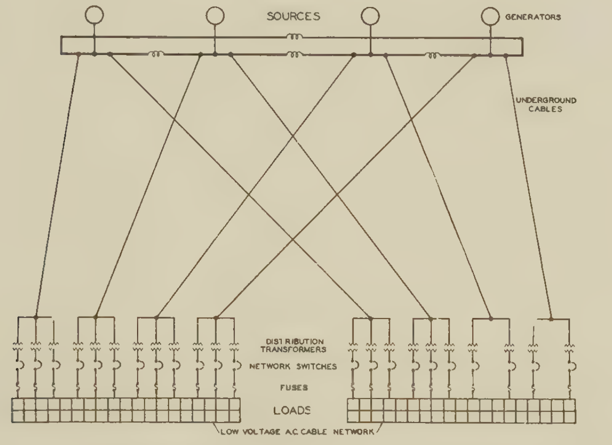

Fig. 2—Schematic Connections Close Linked System

has been designated as the close linked system. With the district arrangement (Fig. 3), or loose linked system, the load is definitely allocated to one adjacent station, wherein it is not essential that it should be maintained in synchronism with the remaining parts of the system. Assuming that the low-capacity ties will open properly on a major fault, this station will operate as an independent unit, alone supplying its particular district.

Characteristics of "Close Linked" and "Loose Linked" Systems

The close linked system requires high rupturing capacity circuit breakers, with increasing rupturing duty as the capacity of the system is increased. The fault protection is complicated, and positive back-up protection is difficult to obtain in case the primary protection fails. During system faults, service voltages are subject to excessive drops due to concentrations of current at the fault. Finally, the entire system service is at stake in case of a series of major faults.

On the other hand, the loose linked system by subdivision of the load, eliminates the likelihood of an entire system shutdown, but it does increase the probability of interruptions to each district. In addition, each station must have some efficient units if economical results are to be obtained. This system, except at district border fringes, cannot obtain the economies and reliability from diversity of a multiplicity of sources of supply. In other words, the loose linked scheme postulates that a power system can become so large that it is either economical, or imperative, to divide it into a number of separate districts power systems in order to obtain reliability.

Improvement in Reliability of Generating Sources

Investigation of the reliability of both the above systems made it appear that a generating station bus system providing parallel synchronizing paths would result in increased reliability to either a close linked or a loose linked system, with either ring or star bus plan. However, such an arrangement increased the switch rupturing duty and the voltage disturbances on system faults. Furthermore, it did not simplify the protection problem.

In 1924, following two years' experience with the Manhattan multiple feed a-c. network system, the author proposed for maximum reliability to operate each generator in parallel with remaining generators only on the low-voltage network.[3] This system uses the load points as a short-circuit-proof paralleling bus for all the units which are "synchronized at the load." In applying the principles established by experience with multiple-feed low-voltage network distribution to a group of generators multipled only on a low-voltage network, it was assumed that if the system were stable, the following desirable conditions would result: (a) highly reliable sources of supply, since they were not affected simultaneously by faults; (b) positive back-up fault protection; (c) minimum fault current concentrations; and (d) minimum service voltage disturbances. The definite evaluation of the synchronizing power available and of the amount necessary to keep sufficient generating sources in step to supply the load under all conditions of system faults presented problems which prohibited the immediate application of such an arrangement. The detailed determinations of these values, both by calculation and test, are described in accompanying papers.

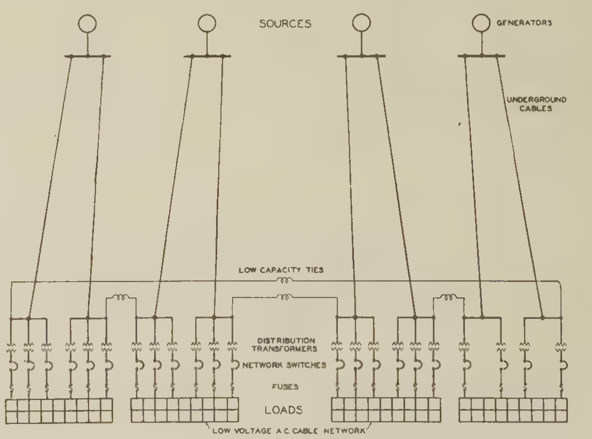

Fig. 3—Schematic Connections Loose Linked System

The synchronizing power for the New York close linked system with this arrangement was found to be adequate. While it is less under normal conditions than that which is obtained between individual units

3. *Underground A-C. Networks*, by A. H. Kehoe, A. I. E. E. Trans., Vol. 43, 1924, p. 848.

synchronized at the sources, yet the effective synchronizing ability at the time of a disturbance is approximately the same as with a close linked system, due to the reduced magnitude of possible faults, and the new system has high reliability due to a multiplicity of independent sources. With a loose linked system the reliability of any district would not be dependent upon the synchronizing ability of the system, but upon that of a single station. For this reason the number of possible independent sources for any district will be less than with a close linked arrangement which is considered preferable to the loose linked system if it is to be "synchronized at the load."

Reliability of Supply Synchronized at the Load

The assurance of reliability of system supply for any one fault is secured by the following considerations: Sufficient generating sources are "synchronized at the load" on a system having ample synchronizing power between the units to produce stable operation between all sources for any single fault regardless of its location, provided the fault is eliminated promptly by protective equipment. So long as enough such independent sources are in service to maintain the load, the loss of the reserve part of the capacity will not result in an interruption, since the remaining capacity is not jeopardized by this loss. The ability of a low-voltage network to eliminate its own faults[4] will provide positive back-up protection even though a reasonable percentage of subsequent failures of protective equipment do not eliminate the original fault. If a system has radial service supplied from a substation, the low-voltage bus, such as a 4-kv. substation bus, will be the last common load point and must be used for synchronizing at the load. In this case, protective devices are relied upon for secondary protection, as there is usually a number of protective devices in series backing up each other for a major fault. In the extreme condition, a fault which is not eliminated because the protective equipment failed will cause an interruption only to the substation where such failure occurs.

System Results Synchronized at the Load

With a system synchronized at the load, the current and load division between feeders may be affected somewhat except for peak conditions, when results should be the same. The magnitude of this effect, however, does not make it of major consideration. Similarly, in order to give the system the reliability obtained by diversity of supplies from a number of independent sources, the load from any generator (or bus section) should scatter to as many different load centers as possible. If this is carried to extremes, the mean length of feeder will be increased unnecessarily. It is pointed out that all units do not have to feed each and every load point, and in the New York case we did not experience any increase in feeder lengths. It should also be noted that additional capacity can be supplied at lower installation costs because of smaller capacity required for electrical connections.

The arrangement makes the maximum short-circuit currents much less than are experienced on a system having a number of generators concentrated on a single bus. Furthermore, additions to system capacity do not increase the switch rupturing duty beyond the amount required by the first installation as long as the same generating capacity is maintained on existing sections.

Since the magnitude of fault currents is materially reduced and since currents from all other units must feed through the load into the fault, the resultant voltage disturbances due to system faults are materially reduced. System service voltages during major faults approximating 60 per cent to 90 per cent of normal are to be expected instead of 20 per cent to 50 per cent of normal.

Conclusions

With ample synchronizing ability inherent in the system to give stability to a number of independent power sources, whether located in one or several different generating stations, generators synchronized at the load can be connected by supply feeders to a number of load points, thus making it impossible for one fault to affect all of the generating capacity; hence, if sufficient reserve capacity is in operation, the loss caused by a single fault cannot affect the reliability. By this method, reliability of supply depends upon having immediately available sufficient spare capacity in operation to compensate for a maximum number of possible major faults which are reasonably likely to occur in the interval required to get spare capacity in operation.

Acknowledgments

Acknowledgment is made to those engineers who between 1924 and 1928 have encouraged the development of the arrangement by stating that in their judgment the synchronizing ability would be ample with the 60-cycle New York City system. In particular, credit for bringing this sytem into operation is due to the Westinghouse engineering staff for its mathematical investigations and conclusions which were proved by test to be highly accurate.

4. *Underground A.-C. Network*, by A. H. Kehoe. A. I. E. E. Trans., 1924. Vol. 43, p. 845. Also, *Extinction of an A-C. Arc*, by J. Slepian, A. I. E. E. Trans., 1928, Vol. 47, p. 1404, and *Theory of the Deion Circuit Breaker*, by J. Slepian, A. I. E. E. Trans., 1929, Vol. 48, p. 523.

Abridgment of

"Synchronized at the Load"—II
Calculations of System Performance

BY S. B. GRISCOM[1]
Associate, A. I. E. E.

Synopsis.—*This paper describes the results of calculations made for operating the Hell Gate and Sherman Creek generating stations of the United Electric Light and Power Company, synchronized at the load.*

After reducing the numerous branches of the system to a simpler equivalent, calculations were made on the operation of an isolated section. These calculations indicated ample static stability and transient stability under fault conditions representing the maximum which might normally be expected.

Other calculations were made indicating that the entire system with synchronizing paths completed through the substation low-voltage busses, would likewise meet the required stability conditions.

Tentative system design factors based on the calculations and experience to date are suggested as a guide to system planning.

This paper shows a practical application of the theories and principles developed in the studies of transmission stability. In the present case, a somewhat different object was in view inasmuch as it was desired to substantiate ideas as to the feasibility of the plan of synchronizing at the load rather than to obtain numerical limits.

* * * * *

Introduction

In general, the principal reason for synchronizing generators at the load is that it gives promise of increasing the reliability of power supply from the generating sources. Having as a background the many papers and technical articles on stability written recently, there is a tendency to associate stability and reliability of service. The subjects are related to the extent that a system which is capable of reliable and continuous service necessarily possesses stability to a high degree. However, with the usually understood meaning of stability, it is entirely possible to have a stable system which may not be capable of service reliability of a high order.

An example will be used to bring out the conceptions of the term "stability" and "reliability" as used in this paper. Assume that a power system is composed of only one generating station and that all of the generators in the station are connected to one bus. Load is distributed from this bus by means of feeders connected to it through reactors of conventional value, as three or five per cent. This system would be considered stable, with generator and excitation characteristics as are in common use. However, the system might not be considered reliable because it has a vulnerable spot—the single generator bus. Major trouble on the bus or on any part of the equipment connected to it could result in a complete system outage. Thus, the system is stable but not reliable. If the bus is divided into a number of parts and the sections thus formed are connected by reactors, the combination would be regarded as having a higher order of reliability than the system with a single straight bus. Similarly, if there are two stations with connecting ties, the over-all reliability is considered as still greater. It will thus be noticed that the insertion of reactance between units of a system has improved the reliability.

Stability Requirements for Satisfactory Operation when Synchronized at the Load

The fundamental plan of synchronizing at the load is described in a companion paper by A. H. Kehoe. This plan gives a redistribution of reactance on the system so that the reactance between machines and in series with faults is considerably increased. Fig. 1

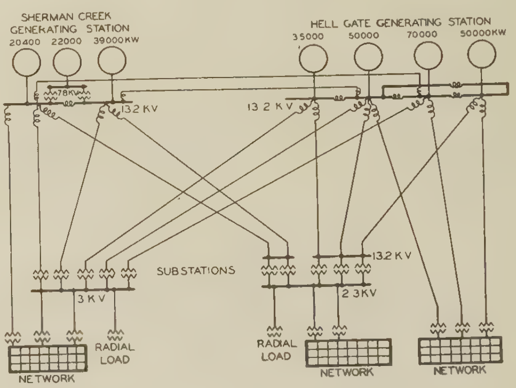

Fig. 1—Synchronized at Generating Station Busses

illustrates in a schematic manner the connections which have been in use in the 60-cycle parts of the generating stations of the United Electric Light and Power Company and in the system external to them. The generating busses were tied to one another very closely, inside the stations, by bus-tie reactors and outside of the stations by cables at generator voltage. The stations themselves were tied directly together by high-voltage cables. Fig. 2 shows the same equipment but synchronized at the load with the reactance between generating units considerably increased by the omission of the bus-tie reactors and inter-station ties, and by splitting the substation high-tension busses. From the stability point of view this scheme of con-

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

nection is only partly equivalent to a ring bus scheme in which high-reactance reactors are used between busses, since the actual ties between units consist of a large number of branches in parallel and because each generator tends to have symmetrical ties with each other generator. In fact, from this point of view, the arrangement is more nearly like the synchronizing bus or star bus, but does not have any points where large amounts of energy are concentrated. The stability and reliability of the synchronized at the load arrangement compared to the previous arrangement depends upon the relative amount of change in reactance in series with faults and between generating units. The calculated performance when synchronized at the load is described in this paper, while the test and operating results are described in the companion paper by Messrs. Searing and Milne.

The rigid requirements for power supply in a metropolitan area necessitate a system which has static stability under all conditions of operation and transient stability under all conditions of operation, with the

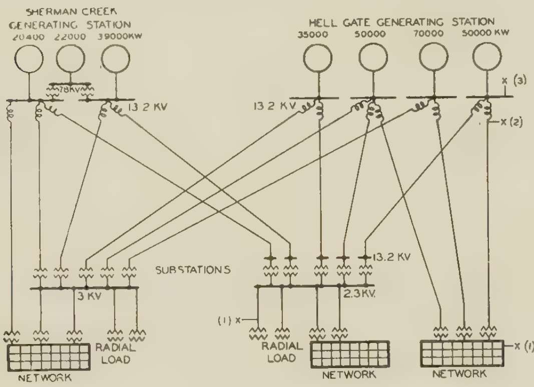

Fig. 2—Synchronized at the Load

exception that in some cases a disturbance may result in loss of a generating unit; and this is permissible, but it is required that the remaining units maintain synchronism with one another. In addition to possessing the necessary stability, there must be no undesirable hunting between generating units. The layout of the system is such that if stability can be obtained, the requisite reliability of service will automatically be obtained, vulnerable points having been largely eliminated.

By static stability is meant that the generating units shall be capable of carrying the required load under normal conditions without loss of synchronism. With such a closely connected system it appeared likely that such would be the case, and the analysis of this point was made largely as a formality.

There are three transient conditions to be considered: One condition is a fault located more or less equidistantly from each of the generating units, as (1)on Fig. 2. From the nature of the layout it is apparent that such a fault affects all of the generators similarly and practically in proportion to the size of the machine, hence, would be almost unnoticed. Another condition is a fault on a feeder close to one generator unit, such as (2) Fig. 2. Practically, this condition resolves itself into a fault on the feeder side of a feeder reactor on one of the generating units. A fault at this location has a tendency to cause the generator nearest it to go out of step. The third transient condition is that of a short circuit on one of the generating bus sections as illustrated by (3), Fig. 2. This condition will almost invariably cause the loss of the generators connected to that bus section. However, it is required that only the remaining generators stay in synchronism with each other.

From the foregoing, it will be seen that the most important considerations from the stability point of view are that all of the generators keep in synchronism for short circuits on the feeder side of a feeder reactor, and that all of the generators except those directly involved stay in synchronism during a bus short circuit. The three-phase short circuit is the most severe and has therefore been made the basis of study.

Methods of Analysis.

There are, in general, three ways of making an analysis for stability; calculation, laboratory tests, and field tests. It was found that the major portion of the work involved was in obtaining values of the various impedances because of the unusually large number of feeders, and since a determination of these values for the existing and proposed system of the United Electric Light and Power Company was a necessary part of the program, all of the analysis was made by calculation. Later, tests were made to give an over-all check on the derivation of system impedances, machine characteristics, and the electromechanical oscillations set up by short circuits.

The general methods of calculation have been described in several papers before the Institute and details will not be given here. In all calculations, the load was considered as a shunt admittance. This assumption was necessary because of the amount of work which otherwise would have been required, but is is probably fairly accurate for the system under consideration because of the relatively large amount of lighting load. For the static stability analysis the synchronous reactances of the generators at the initial operating points were used. For the transient analyses the transient reactances of the generators were used. The effect of variations in the cross flux was not considered. Decrements of main field flux, and the general method of calculation were about as given in another paper before the Institute.

The studies which were made were divided into two groups, one being on a portion of the system which, in addition to lending itself readily to tests, also is of the type representing what appears to be the tendency in the growth of the system. This part of the system

2. *Studies of Transmission Stability.* Evans and Wagner, A. I. E. E., Trans., Vol. 45, 1926, pp. 51-94.

was that which was fed mainly by the 120-208-volt a-c. network system. Other analyses were made covering the entire system as it was expected to be when the plan was first placed in operation. The discussion will therefore be divided between the analyses of one generating unit split from the system and operating on the networks, and the entire system with generating units separated at the generating station and synchronizing ties through the low-voltage substation busses.

Partial System Analysis

Reduction of Network. The part of the system analyzed is shown by Fig. 2 in the companion paper *System Tests and Operating Connections, Synchronized at the Load.* In this figure, each small square represents a networked area and consists of hundreds of branches. After having obtained the reactance of the network elements, values were substituted for the small squares of Fig. 2 of *System Tests and Operating Connections,* (Part III of this symposium), in accordance with the transformer capacity connected to the various cables. The effective reactance between the generator to be tested and the remainder of the system, through the networks was found in this manner. Resistance components were then added to the reactances according to what was considered to be the probable ratio of resistance to reactance. Admittances were placed along the connecting impedance between the two generating sources in proportion to the probable electrical distances of these loads from the sources. This gave a static network to which it is only necessary to add the generator reactances to proceed with the analysis.

Static Stability. The synchronous reactance of the generator under test and the remainder of the generators grouped were added at the proper ends of the connecting network, and, with the internal voltages determined in accordance with the initial loadings, completed the data necessary for obtaining a static power-angle diagram. Points were picked off of this characteristic and the generator terminal voltage computed to give the points of the voltage-power characteristic of Fig. 3, this form being more readily interpreted. It will be noted that with an initial load of 22,000-kw. at 100 per cent voltage the static stability analysis indicates that with fixed field excitation, a load of 31,500 kw. could be carried before pull-out takes place at 88 per cent voltage. This, of course, does not mean that a load higher than 31,400 kw. could not be carried, but merely represents the approximate margin for a given initial load and corresponding field excitation. This analysis indicates that there is ample static stability without the use of automatic voltage regulators.

There was some speculation as to the possibility of hunting, but this factor cannot readily be examined in advance. It was felt, however, that no hunting would occur, and when tested this was found to be the case.

Transient Stability. Analyses of transient stability were made for three-phase short circuits on a feeder, both at some distance from the station, and just outside the station where the feeder reactor was the only impedance in series with the fault and the bus. These analyses were made by the point-by-point method, calculating the changes in field flux and angular positions, and indicated that stable operation could be obtained under these conditions.

Tests were made with faults of various severity and duration, checking the general methods and conclusions, that with the reactances and short circuit currents obtaining when synchronized through the network, the system would be stable. These tests showed that the equivalent reactance between the tested generator and the remainder of the system was about 46 per cent based on the machine rating. The maximum short circuit was 2½ times rated generator current (instantaneous symmetrical) and the maximum duration of short circuit was 1.8 seconds. The initial

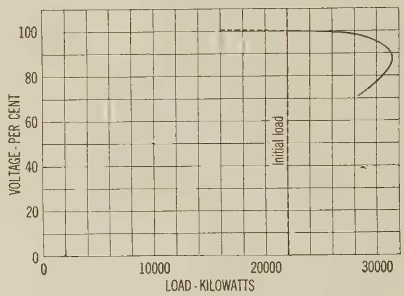

Fig. 3—Voltage-Power Characteristic, Indicating Static Stability

load was approximately 60 per cent of rated load, at rated power factor and no automatic voltage regulators were in use. The generator had a short circuit ratio of 0.76. These figures show quite clearly that *high short-circuit ratios are not required of turbo generators for power supply in relatively closely connected system.*

Entire System

In analyzing the entire generating system of the United Electric Light and Power Company, there are two transient stability requirements to be met as well as the static stability requirement. It must be capable of withstanding a three-phase short circuit on one of the generating busses without the other generators losing synchronism, and it must be able to withstand feeder short circuits. It was not considered necessary to repeat the analysis of static stability in view of the results obtained on the portion of the system previously analyzed.

The proposed initial layout for synchronizing at the load is shown in the companion paper by Messrs. Searing and Milne and it will be noted that the synchronizing tie in this case is principally through the substations rather than through the a-c. low-voltage network.

A calculating board set-up was made as in the previous

studies to obtain the equivalent mesh of the ties external to the generating stations. The reactances of the various generators were then added to the mesh, and another calculating board study made for the equivalent mesh including the internal reactances of the generators. The following table shows the per cent reactance between the internal voltage of the generators connected to each bus and the internal voltages of all other generators combined, based on the combined ratings of the generators connected to the bus in question.

Bus section	Per cent reactance
N. E.	30 per cent
S. W.	29 per cent
4	50 per cent
5 and 6	50 per cent
7	50 per cent
8 and 9	52 per cent

These values indicate that the system is at present somewhat unbalanced with reference to the synchronizing power of the various generators. This is due to a temporary local condition in that the feeder capacities at Hell Gate and Sherman Creek are not in proportion to the generator capacities. This condition will gradually disappear as cable rearrangements and additions are made.

Bus Short Circuit. A solid three-phase short circuit

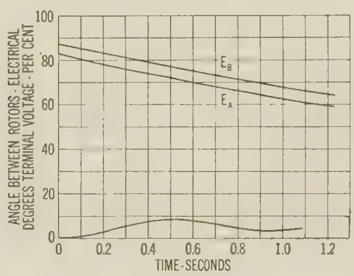

Fig. 4—Effect of Bus Short Circuit with Entire System Synchronized at the Load

was considered as applied to the bus section which gave the largest short-circuit current. Under this condition, the generators operating on this bus section immediately lose all of their load, and over-speed. The resultant effect on the other generating bus sections depends upon how much dissymmetry there is in the layout. With an entirely symmetrical layout, the other generators would tend to speed up in unison with no tendency to lose synchronism with each other. In order to simplify the analysis, the results were calculated on the basis of reducing the system to two equivalent generating groups. One of these groups included those generators on the bus section having the maximum differences from the others, while the remaining generators were grouped together.

Fig. 4 shows the results obtained. It will be noted that the angular oscillation between the generating groups is very small, and that the drop in voltage is quite nominal considering the character of the fault condition. This analysis indicates that the proposed scheme can operate and furnish stable and reliable service with a solid three-phase short circuit on one bus, provided there is enough generating capacity in reserve, and provided that the bus section is isolated in a reasonable time by the opening of feeder switches.

Feeder Short Circuits. A transient stability analysis was next made with a short circuit on the feeder side of a feeder reactor, the reactance of which was such as to produce a short-circuit current of three times the full-load current of the generators connected to the bus. To facilitate calculations, the generators were grouped so that those on the bus having the short-circuited feeder constituted one group, and all other generators the other group. The results of this analysis are shown by

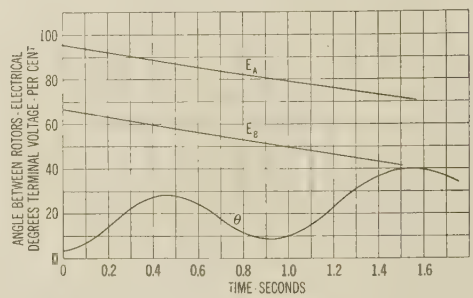

Fig. 5—Effect of Feeder Short Circuits with Entire System Synchronized at the Load

Fig. 5. It will be observed that this condition sets up a considerably larger oscillation than the bus short circuit, but that considerably less voltage disturbances are set up. This calculation indicates that short circuits up to three times the current rating of the nearest generators and having a duration up to about two sec. can be handled successfully. However, where possible, both the current magnitudes and duration should be reduced, as this will constitute less hazards and give less voltage disturbance.

Tentative Design Constants

From the studies and tests made thus far, the following values are suggested as reasonable for system design.

Synchronizing Ability between Generators. The impedance between the internal voltage of one generating unit and the internal voltage of all other units of the same system in parallel (not including ties to other systems) should lie between 40 and 60 per cent, based on the kv-a. rating of the generating unit.

Synchronizing Ability between Systems. The impedance between two systems both of which are synchronized at the load should not exceed 200 per cent on the rating of the smaller of the two systems.

Short Circuits. The maximum instantaneous symmetrical short-circuit current on a feeder from a

generating unit should not exceed 2½ times the normal current capacity of the generating unit and should not be permitted to last longer than 1½ sec. For simplicity this value should be obtained on the basis of a short circuit with the highest capacity feeder reactor in series with the generating unit on a three-phase short circuit. For higher values of short-circuit current the duration of short circuit must be reduced.

Circuit Breaker Capacity. With the above system proportions, the interrupting duty on a generating unit breaker will not, in general, exceed 1¾ times the generator short-circuit current.

Abridgment of

"Synchronized at the Load"—III

System Tests and Operating Connections

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and

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Synopsis.—*System test results, operating connections, and experience with the New York City system synchronized at the load are given. Data obtained by test are presented, showing the behavior of the system when generators are operated synchronized only through a low-voltage a-c. secondary network.*

The adaptation of this method of connections to the New York City 60-cycle system, including system layout, station and feeder rearrangement, and automatic recording apparatus, is described.

Experience with these connections has demonstrated that stable performance of prime movers is obtained, load and wattless control is simplified, oil circuit breaker duty is reduced, and voltage fluctuation at customer's service during system disturbances is materially decreased.

* * * * *

THE New York City 60-cycle system is principally supplied by the generating stations of the United Electric Light & Power Company with interconnections to the Brooklyn Edison Company system. Primary energy is supplied to the United distribution system on Manhattan Island and to the Bronx, Westchester, and Queens districts.

Two stations—Hell Gate with a 60-cycle capacity of 500,000 kw. and Sherman Creek with a 60-cycle capacity of 105,000 kw., supply the systems. In addition to the interconnections with the Hudson Avenue Station of the Brooklyn Edison Company, there are connections to the 25-cycle system through five frequency changers, aggregating 185,000 kw.

The 60-cycle distribution load on Manhattan is supplied almost entirely by multiple feed low-voltage networks, having a total connected transformer capacity of 100,000 kv-a. Similar networks are in operation in the Bronx and in parts of Queens. Service to the remaining districts, as well as the major supply to these networks, is furnished through conventional distribution substations. In network districts, however, the building of new substations has been discontinued and the distribution transformers are supplied at generator voltage.

The high degree of service reliability required by high-load density districts called for a system superior to the usual radial arrangement. This led to development of the multiple-feed a-c. low-voltage network which was first placed in service in Manhattan in 1922. Experience with this system of distribution with rapidly expanding application indicates that the reliability of service is now limited by that of the generating sources.

Operating experience has shown that a bus fault on the conventional ring bus arrangement of generator connections with high-capacity interstation ties will cause outage to parts of the system, and serious disturbance to the remainder.

The companion papers describe a new arrangement of system connections to the generating sources—synchronized at the load—which applies the principle of multiple feeds upon which the network distribution system is based.

With this arrangement, a generator about to be placed in service is first synchronized with an adjacent unit and connected to the bus in the usual manner. After the generator is supplying the load of the bus section to which it is connected, the high-tension connections to the adjacent unit are opened, leaving the generator connected only through the low-voltage networks.

Experimental Determination of Network Impedance

The proposed arrangement, contemplated a system in which the only connections between generators would be those through the secondary network. While the system constants from the generator to the network were susceptible to accurate calculation, there was no information available as to the impedance of the

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secondary mains system; hence, it was desirable to obtain test confirmation of the calculated values.

The results of this test, which was made on the Times Square network, showed the impedance of the network from the transformer terminal points of any feeder to an imaginary star point to be 5.1 per cent, based on the transformer kv-a. connected to the feeder.

The value of 5.1 per cent agrees reasonably well with a calculated value of 4.6 per cent for a similar case when it is considered that the calculations were made on a different network (Inwood) and the network under test was distorted by having two of its normal feeders out of service.

System Tests

Calculations made on an arrangement in which one of the generators was connected to the remainder of the system only through low-voltage networks, forecasted successful operation during normal loading and feeder short circuits on the system connected to this generator. Therefore arrangements were made to test the performance of one generator at Sherman Creek Station synchronized with the remainder of the system through the Manhattan secondary network.

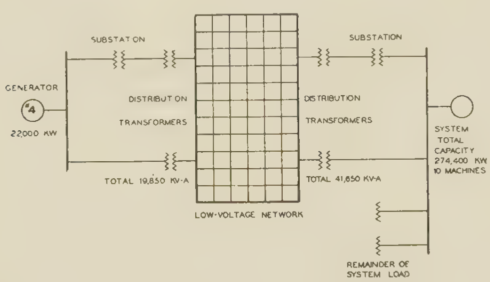

Fig. 1—Schematic Connections for System Test

Due to the limited capacity of network feeders available for this purpose, the coupling between the generator thus isolated and the remainder of the system was small when compared to the generator capacity, and therefore the test conditions were more severe than would be expected under an arrangement where the generator capacity and network interlinkings were comparable. The specific purposes of the test were to determine the stability of a generator operating under such conditions and subjected to feeder short circuits, to check the action of automatic network switches having sensitive reverse power settings, and to determine the effect of such operation on the customer's service.

The system connections at the time of test are indicated in Fig. 1. Generator No. 4 was connected to the low-voltage networks through a number of feeders having a total connected distribution transformer capacity of 19,850 kv-a. The remainder of the system was connected to these same networks through distribution transformers, totaling 41,650 kv-a.

During the test, the approximate loading was 12,000 kw. on generator No. 4 at Sherman Creek and 218,310 kw. on the generators connected to the main system, of which it is estimated 25,200 kw. was supplied to the low-voltage networks included in the test.

Neglecting the effect of network load, the impedance between generator No. 4 and the remainder of the system including internal reactances of all machines was approximately 60 per cent, based on the rating of generator No. 4, 25,900 kv-a. During the tests, all feeder regulators were on automatic operation. All generators on the system are arranged for manual excitation control.

On May 7, 1928 the two systems were set up and operated, synchronized through the low-voltage networks from 8:52 p. m. to 9:57 p. m. Although no short circuits were applied, the machine showed no signs of hunting and at all times gave stable operation. During the evenings of May 8, 9, and 11, the two systems were set up and a total of nine three-phase short circuits was placed on the auxiliary system, each short circuit being cleared automatically in a predetermined time. These short circuits were made at various locations over a 7.8-kv. feeder, the last three being applied directly outside the feeder reactors at the generating station.

Oscillographic equipment was used at Sherman Creek to measure:

a. Current and power of short-circuited feeder
b. Terminal voltage of generator No. 4
c. Voltage of main system at Sherman Creek
d. Differential between above voltages
e. Differential watts using current of generator No. 4 and differential volts
f. Current, power, throttle position, and field current of generator No. 4.

In addition, stroboscopic equipment was used during the tests to view the rotor displacement of generator No. 4 during the disturbances.

Nine recording voltmeters were installed at various locations on the networks to obtain a record of the voltage dip caused by the short circuits.

The total number of network switches involved in these tests was 649, of which 208 were connected to the auxiliary system and 441 to the main system.

A summary of the results of all the short-circuit tests is given in Table III. Detailed results of the short circuit applied just outside the station reactors for 1.24 sec. are given in Fig. 4.

Stability

The test results showed that the generator was very stable when synchronized through the low-voltage networks, although the capacity of the connected distribution transformers was less than would be expected under normal system planning. No hunting occurred and even with the most severe short circuit applied just outside the feeder reactors at the generating station for 1.8 sec., the stroboscope indicated a maximum shift of 40 electrical degrees lead between this machine and the remainder of the system.

TABLE III
SUMMARY SHORT-CIRCUIT TESTS SYNCHRONIZED AT THE LOAD MAY 7-11, 1928

Date	Time	Duration seconds	Load on gen. No. 4 kw.	*Current in short circuited feeder amps.	Power in short circuited feeder kw.	Voltage drop at gen. No. 4 per cent	Voltage drop on networks per cent		†Max. swing of gen. No. 4 during short-circuit electrical degrees
							Max.	Min.	
5– 8–28	9:00 p.m.	0.29	13,500	2010	3800	16	13	8	4 lead
5– 9–28	8:15 p.m.	0.28	11,500	3120	9400	21.5	16	10	8 lead
5– 9–28	8:35 p.m.	0.55	12,500	3090	9400	28.5	21	11.5	8 lead
5– 9–28	8:57 p.m.	0.92	11,700	3120	9400	28.5	21	13.0	9 lead
5– 9–28	9:15 p.m.	1.35	12,750	3120	9400	31.0	21	11.5	15 lead
5– 9–28	9:41 p.m.	1.82	12,750	3120	9400	31.0	21	12	19 lead
5–11–28	8:20 p.m.	0.67	12,500	4720	..	44.5	33	19.5	26 lead
5–11–28	9:02 p.m.	1.24	12,250	4720	800	45.0	34	19	34 lead
5–11–28	9:20 p.m.	1.80	12,900	4720	..	44.5	33	20	40 lead

*Instantaneous symmetrical r. m. s. value.
†As viewed with stroboscope.

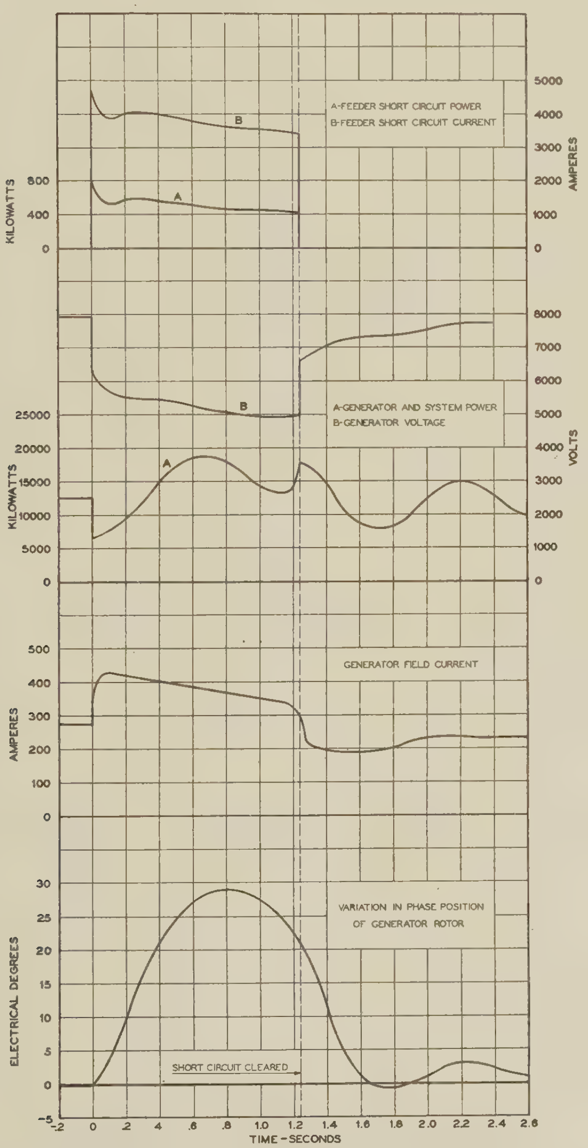

FIG. 4—PERFORMANCE CURVES OF GENERATOR NO. 4 AND SHORT-CIRCUITED FEEDER. TEST OF MAY 11, 1928, 9:02 P. M.

Network Switch Operation

The tests demonstrated that when the system was operated so that the maximum kw. load imposed by a feeder short circuit did not exceed the normal kw. load on the generator, network switches of the sensitive reverse power type remained closed even under the most severe condition of feeder short circuit. The voltage on the network was sustained at a value which precluded any network switches of the low-voltage release type from operating prematurely due to low voltage. During the test, a maximum of 1.4 per cent of the network switches connected to the machine under short circuit opened and reclosed.

System Disturbances

On the networks which were partially supplied by the machine under test, the voltage drop on short circuit varied from 10 per cent to 34 per cent. It should be noted that this drop was much larger than should occur in normal operation because in the test the network capacity was distributed in such a manner as to give the equivalent of a two-circuit network.

System Layout for Initial Operation

These tests demonstrated the stability of the arrangement for any disturbance beyond the feeder reactors and substantiated the general method of analytical treatment.

It was decided to proceed with the layout for operating the entire system synchronized at the load. As there were not sufficient networks to adopt the scheme in its entirety, the 4-kv. substation busses were considered as load points and feeder connections arranged so that the coupling between generating bus sections was provided through transformation and highly reactive ties. This was a departure from the original concept, but not from the basic principle, and represents an expedient to be utilized only until sufficient network capacity is available to complete the entire plan.

Calculations made on the proposed connections indicated that under the conditions of a bus short circuit on one section, all generators, except the one short-circuited would remain in synchronism.

It was not desirable, however, to subject the system to a bus short circuit under this arrangement in order to check the calculations and therefore it was decided to proceed with operation under this plan and provide automatic recording apparatus which would give test data under the normal system disturbances from which

the system behavior under a bus short-circuit condition could be predicted.

Nine-element oscillographs were installed at Sherman Creek and Hell Gate arranged for automatic operation. The principal measurements are those of phase angles between a common average system load voltage and the internal voltage of each generating group which is available at all times by means of pilot generators coupled to the shafts of the mains units. Various other data are recorded to assist in predictions of system behavior.

In planning the system layout for operating synchronized at the load, it became apparent that the ratio of feeder capacity to generator capacity should be approximately the same for all sections; and that any substation or network district should be supplied from different generating station sections so as to maintain diversified feeds under all operating conditions. The first feature is desirable, not only for load division but in order that each generating section may carry its share of the system wattless kv-a. The second feature is obviously necessary for service reliability. Furthermore, the feeder grouping and capacity mu stbe such that generating units and also stations may be loaded to their economical point.

The general plan of operating the entire system synchronized at the load contemplated keeping the tie feeders between Hell Gate and Sherman Creek open at all times. Each of the 13.2-kv. bus sections, four at Hell Gate and two at Sherman Creek, would operate as separate sources during the peak period.

During the light-load period, Hell Gate would operate in two sections and Sherman Creek as a single-bus station. It should be realized, however, that these operating arrangements are flexible and Hell Gate has been operated with various grouping of sections.

As Sherman Creek had too much feeder capacity in proportion to generator capacity, some of the feeders serving the Manhattan and Bronx Districts were transferred to Hell Gate. At each generating station some rearrangement of feeders on the various groups was necessary in order to diversify the feeds to any given substation or network district under any of the various generator groupings. Furthermore, in some substations, no sectionalizing switches were available to permit connecting feeders directly to transformer banks and it was decided to sectionalize permanently the main bus of such stations.

While copper ties between bus sections were avoided wherever possible, it was necessary to continue the highly reactive high-tension loop customers to supply large customers.

The high-tension tie feeders between the Hudson Avenue Station of the Brooklyn Edison Company and Hell Gate were continued, and the reactance value of these ties (112 per cent based on Hudson Avenue) was found to be well within limits.

The Queens district lies between Hudson Avenue and Hell Gate and the increase in load in this district necessitated additional feeders from Hudson Avenue. Accordingly plans were made and work is under way to maintain synchronism between Hell Gate and Hudson Avenue through the 4-kv. busses of the Queens substations, and through frequency changers connecting to the common 25-cycle system of the allied companies.

In order that a unit may be stable under the condition of feeder short circuit, the ratio of short-circuit current to generator full load should not exceed a value tentatively set at 2.5; and the system was set up so that all usual feeder faults would fall within this ratio.

Reduction of Oil Circuit Breaker Duty

One of the advantages of the proposed arrangement was evidenced in the reduction of oil circuit breaker duty. Hell Gate Station was originally planned for five 50,000-kw., 60-cycle units and the main oil circuit breakers which were rated at 1,500,000 kv-a. were of ample capacity to clear a bus short circuit.

This initial layout was greatly exceeded, and one of the problems introduced by the installation of two 160,000-kw. turbines to complete the station was the fact that the breakers would be unable to clear a bus short circuit which gave a calculated instantaneous symmetrical value of 2,900,000 kv-a.

With the synchronized-at-the-load arrangement, the duty on oil circuit breakers was reduced and one of the immediate advantages aside from increased reliability was the fact that maximum duty on these oil breakers would still be within their rated capacity.

Operating Experience

The proposed system layout contemplated generator No. 8 (160,000 kw.) being in service at Hell Gate. Since this generator was not available, it was decided to proceed with the program with modifications, using existing capacity.

The modified arrangement was placed in operation February 13, 1929, when Hell Gate and Sherman Creek Stations were operated "synchronized-at-the-load" with Hell Gate connected to the Hudson Avenue Station of the Brooklyn Edison Company, through the high-tension tie feeders. Tests were made to determine the extent to which the system wattless kv-a. could be controlled in each of the two generating stations, and in general, it was noted that wattless control was more flexible than under the prior arrangement.

Previous to the new operating arrangement, because of its high feeder capacity, Sherman Creek was necessarily operated to prevent wattless kv-a. overloading at a lower voltage than Hell Gate. With the set-up of the new system, however, the wattless kv-a. is more easily controlled than formerly. Up to the point where a feeder becomes overloaded, load may be shifted from one section to another by the turbine throttle,

after which further load shift must be effected by switching banks from one feeder to another at the substation.

While the main synchronizing path is at present through the 4-kv. substation busses, a number of generating station feeders connected directly to the network. No difficulty has been experienced with the network switches which are of the sensitive reverse power type.

The voltage of the system is considerably less affected by feeder short circuits under the new arrangement. The disturbances caused by faults on a high-capacity feeder showed an average voltage drop of 9 per cent synchronized at the load compared with 20.7 per cent with the previous connections.

All generating units have operated in a steady manner both with normal loading and under a number of system disturbances. Records from the automatic oscillographs recently installed will give quantitative information as to system performance.

Test results have verified the calculations, and operating experience thus far has substantiated the predicted advantages of a system synchronized at the load.

The Engineer, Practical Idealist

President's Address*

BY R. F. SCHUCHARDT

THE Institute, meeting here in convention on the "stern and rock bound coast" of New England, finds itself on historic ground. In this region are located many battle fields, of arms and of intellect, that have left their deep impress on our civilization. The battle fields of arms are marked by monuments that are now shrines of an appreciative people. The battles of the intellect, though often accompanied by bloodshed, are not so well remembered. Bunker Hill is fresher in our minds than are Salem and Roger Williams, yet Williams' heroic struggle for freedom of thought paved the way for that later struggle marked by the shaft on Bunker Hill.

The freedom we enjoy today, freedom of thought and of political action, we owe to those who fought and suffered and bled in generations past. We are worthy possessors of our heritages only if we in turn give thought to the morrow, and in our work today plan so that the morrow will offer a richer life for our children.

Are we of the engineering kinship, who are presumably well trained to determine facts and to reason from them, giving sufficient thought to the morrow? It is well on this occasion, in the atmosphere of these significant historical surroundings, to pause a few moments before taking up the technical part of our work, to consider briefly some problems of this interesting workaday world of ours, to try to glean from the study some of the trends in our civilization and our relation to them.

If it is true, as Professor East has written,[1] that man stands today at the parting of the ways, with the choice of controlling his own destiny or of being tossed about by the blind forces of his environment, then it will be well for the engineer to concern himself more with the environment. He should take a larger part in the leadership seeking solution for the human problems that vitally influence the trends. Surely the bewildering complexities of today require clear thinking, and who is better fitted for a thoughtful analysis of the factors on which development and progress depend?

With this as a background, I should like to suggest some thoughts that appear worthy of your careful consideration.

The history of mankind shows a successive rise and decay of great civilizations. Reflection on this leads to the frequent questions: Is our civilization headed for decay? Are we also, like former ages, unable to bear up under prosperity and power? I shall not venture an answer, but let us consider some facts. Earlier civilizations existed on relatively small areas. Today the entire world is a neighborhood —made so largely by the work of the engineer. Not only is it a neighborhood world but also a much more densely populated world, and the great increase in population, we are told, started with the industrial revolution in the eighteenth century—also based on the engineer's work. The engineer, responsible for so much that *is*, cannot shirk his responsibility for correct guidance of what *shall be.*

Our civilization has come to be known as the Machine Age and as such it is both lauded and condemned. President Glenn Frank* in a splendidly balanced analysis of the machine age and its trends, offers this comment:

". . . the masses have more to hope for from great engineers, great inventors and great captains of industry than from the social reformers who woo them with their panaceas. The greatest social progress of the next fifty years is likely to come as a by-product of technical progress."

Even in the Orient, where the materialism of the Occident is thought to sound the death knell of the spiritual, we find the famous Chinese philosopher, Dr. Hu Shih, in agreement, for he sees science and the new technology as the forces which restored to man a sense

1. "Mankind at the Cross Roads" by Edward M. East.

**Delivered at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.*

*"Where is this Machine Age Taking Us" by Glenn Frank, in *The Magazine of Business*, Oct. 1927.

of self confidence and thus created the modern civilization of the West. He concludes that inventors, scientists and producers of goods deserve the blessings of their fellows as spiritual leaders.

Others of the interesting group that contributed to the symposium, "Whither Mankind," inspired and edited by Charles A. Beard, seem to concur. As Dr. Beard summarized in part; "They are not oblivious to the evils of the modern order, but they do not concede that any other system, could it be freely chosen in place of machine civilization, would confer more dignity upon human nature, make life on the whole richer in satisfaction, widen the opportunity for exercising our noblest faculties, or give a sublimer meaning to the universe in which we labor.'

With these encouragements let us try to see some of the things about us as they are. Let each of us compare this world of our experience with the dream world of our ideals. Let us see if as engineers we have not an exceptional opportunity to gain in our individual lives that true satisfaction which comes from an attempt to leave the world a better place than we found it. But first let us recognize that an engineer today is far more than Treadgold defined him nearly a century ago. In addition to "directing the powers of nature for the service of man" he now adds to the common welfare also in fields more human. He finds himself occupied at times in social guidance so that the tools he has provided shall be properly used

One of the most significant and important trends of this day is the continuing movement of population from the rural regions to the urban; which, with the great increase in the world's population, is thus rapidly accelerating the growth of cities. The engineer's machinery makes it possible to provide the necessary food with the expenditure of a lesser manpower than formerly and his transportation developments readily bring the food to the urban population. But with rapidly increasing population the problem becomes more and more difficult.

Professor East cites figures to prove that the maximum food supply that can be produced on the land area of this globe available for that purpose will support a population of fifty-two hundred millions, a figure which at the present rate of increase, he says, will be reached in about a century. Long before that time it will become necessary to bring into production land which is now largely arid and difficult of access, and even then, occasional crop failures will result in widespread starvation.

We can leave to the medical profession and to the biologists the task of checking population increase, but let us engineers face some of the attendant problems. We are not directly concerned with the exact decade when world saturation will be reached but we are vitally concerned with the provisions for living and for advancing civilization while man's neighbors are crowding closer and closer. The marvels of science have lulled the layman into a false sense of security. They have given him faith to believe that with the scientist and the engineer on the job the future will take care of itself. Perhaps it will, but only if the thinkers and the doers of this generation and those who follow put themselves earnestly to the task. Intelligent thinking usually leads to intelligent action. No engineer worthy of the name can take a laissez-faire attitude on problems that deeply affect human welfare and progress.

How does the engineer picture the future city? Is it to be a mechanical Colossus full of ingenious provisions for commerce and industry, for housing and for getting about, or will it be a place where man still has some contact with nature? The growth of our cities is both upward and outward. The upward limit is moving higher and higher, for both business houses and multiple dwellings, and all of the ground area that was formerly devoted to low buildings is being covered by the higher structures. The engineering problems of transportation, of light and air and health for the highly congested population are not impossible of solution but we must admit that they are being taken care of only in part. Multiple decked streets above and below ground, huge ventilators, air conditioning devices, artificial light and other necesssary contrivances are relatively easy to plan, though some of them are very expensive to provide; but is the sort of civilization that is likely to develop in a city of that character the kind that makes for a richer and nobler living? Are we building the City and forgetting the Man, as Grosvenor Atterbury[2] suggests, and are we not fast losing our sense of values?

You remember the Greek legend of Hercules and his encounter with Antaeus, the giant whom Hercules met when on his trip to get the golden apples. Antaeus was a son of Mother Earth and each time he touched the ground his strength grew tenfold. Hercules wrestling with the giant noticed this increased strength so he finally caught him up and held him in the air. Then, no longer having contact with Mother Earth, the giant's strength sank and life ebbed away with it. Is this not symbolic of man's experience when contact with nature is lost? Can a life develop properly when shuttling in crowded cars, through crowded streets or supercrowded subways, between an office which sees the sun for twenty or forty minutes a day and an apartment home in a high building closely touching elbows with neighboring high buildings? Is there a social problem involved in such city building and has the engineer no concern in it?

Our physical surroundings, things we can change if we will, offer a fertile field for the interest of engineers with their vision and with their desire for lifting life to higher levels. I suggest that we give more study to this and similar city problems and that we occasionally discuss them at Institute meetings, especially in our metropolitan sections.

Let us consider some of the problems that are, as

2. "Our Monster City and Its Life" in *N. Y. Times Magazine*, Jan. 13, 1929.

it were, at our elbow. One is that of automobile engine exhaust in our cities, which has received all too little attention. This presents a serious health problem in the deep canyon-like streets. Investigators of carbon monoxide poisoning declare that this deadly poison is often found in city streets in sufficient quantities to impair health, and in some instances to be the proximate cause of death. And with the traffic jams on country highways, the holiday outing is now far from a health trip.

While on the subject of air pollution let us in passing note the factory and the apartment house chimmeys that still frequently belch forth dense clouds, often robbing man of beauty and of health. The engineer has provided a partial cure, but even our giant power stations, which receive the most expert engineering attention, still leave something to be desired.

There is another handicap to which little thought is given,—the deleterious effect of noise on the nervous system. Scientific tests have shown a marked reduction in labor efficiency due to noise, and British physicians have even advocated an act of Parliament prohibiting needless noise in the interests of the nation's health. Certain it is that our present day business and professional life draws heavily on our nerves, and all too many men collapse under the strain. Relief from noise as one contributor to the strain is thus a direct public benefit.

And how much are we interested in the backyard regions of our industrial cities? Many of these reflect little credit on our advanced civilization. Disorderly dumpheaps and scrap piles are still all too common. They enrich no lives spent among them; rather they are likely to develop that element in our citizenry with which the forces of law and order are in constant conflict. The appalling waste that this entails affects much more than our taxes. Good housing and neighborhood cleanliness go far toward making life for the lowly conform more nearly to the picture of today's accomplishments that we paint with such pride.

The engineer knows that most of our cities have grown more or less hodge podge during the crude developmental years of our country. He knows also that correct growth demands guidance, and this means a city plan. Fortunately many cities, taking the lesson from the important European centers, have seen the wisdom of proper planning and are correcting misfits of earlier decades and are providing better guidance for the future. But the problem is today one of even greater extent—one of regional planning, and engineering enters largely into this also. Here is a field which arouses the enthusiastic interest of every true engineer. He realizes that the suburban regions are rapidly filling with dwellings and to some extent with factories. He knows that if life is to be lifted to better things these newer developments must be coordinated properly so health, convenience, beauty, and the opportunity for wholesome family life may all be properly provided for. In this and similar activities the engineer will seek the greatest dividends in terms of human happiness.

The increasing population, Professor East says, requires that each year forty million acres more must be tilled and harvested than the year before to provide sufficient food, and this clearly makes countries more and more dependent on one another and at times will shift the direction of the dependence. The engineer has brought countries together by rapid transportation, by land, by sea and by air, and has tied them still closer by achievements in communication, and now even by international power lines. What can he do to hold them together as friendly neighbors? The answer here goes to the very bottom of man's relation to man.

The material work of the engineer deals with nature's laws. He knows he must understand these laws and must use truth in his work or it will fail. Engineering analysis applied to human relations similarly seeks to find the underlying laws. A study of past civilizations indicates that they failed because of violation of that basic social law which bids us do unto others as we would have them do unto us. Is it too idealistic to expect improvement in our day to come as a result of more engineering in government, that is, more of the engineering method applied to the solution of questions that tend to bring discord between peoples and between people? There is encouragement in the statement made by Bertrand Russell,[3] "I look, therefore, to the western nations, and more particularly to America, to establish first that more humane, more stable and more truly scientific civilization toward which, as I hope, the world is tending."

Technical achievement has almost eliminated manual drudgery. The habit of technology to be guided by basic law holds out promise that "man's inhumanity to man" may likewise be banished. Is this also too optimistic? Has human nature remained unchanged through the ages, as is so often stated? May I refer the pessimists, if there be such here, to any story that portrays life during earlier periods, as for instance, "Power" by Leon Feuchtwanger. The reader of this gripping tale of the ruthless standards of the eighteenth century will congratulate himself that he is living in the twentieth.

Our machine civilization is still young, and we can attribute to growing pains many of the conditions that today prevent man's best development. However, a look toward the horizon will show many encouraging signs.

Our country, appreciating the keen need of the time for the engineering approach to the important problems of state, has elected an outstanding engineer to the presidency. In other countries the engineer must similarly stand at or near the helm if this civilization is to survive. This does not mean that he alone is to be the savior of mankind, but in this age of cooperation, the engineer, together with the doctor, the lawyer, the economist, the sociologist and other trained minds, must apply himself to a scientific solution of social

3. "Whither Mankind" edited by Charles A. Beard.

problems in addition to furthering material development. He must join forces with all those

> ". . . . whose law is reason; who depend(s)
> Upon that law as on the best of friends,"

with men who can find facts and who can face them boldly and honestly.

The engineer's work has started many trends in the direction of relief from some of the world's growing difficulties. A notable one is the spread of electric power into areas away from congestion, thereby permitting at least a partial decentralization of industries and of population. This spread is greatly advanced by the interconnection of power systems now so common all over the country, while the ease of getting about with automobiles is another important factor. A further material aid is the extension of electric distribution lines into rural regions so that modern methods can be applied increasingly to agriculture, both in the field and in the home, while the telephone and radio are keeping farm operators in touch with the latest in music and education. Great as the progress has been, much still remains to be done in these fields.

Among other items that bring cheer and stimulate optimism may be mentioned the increasing interest now being taken in sane city and regional planning, the efforts of important industries looking toward elimination of waste and the conservation of our resources, the conversion of former wastes into profitable by-products and particularly the growing reclamation of wastes in agriculture.

But here is a bit of pessimism.—The high speed at which life seems to be driven today and the apparent immersion of large numbers in gross materialism has filled some people with fear and misgivings regarding the future. Thus we have the Bishop of Ripon seriously suggesting a ten year holiday in science to give the culture of the soul an opportunity to catch up with the rapid material progress. But the fear that the "spirit" cannot grow in an atmosphere of "science" is not a new one. A century ago Edgar Allen Poe in his Sonnet to Science wrote in part

> "Hast thou not dragged Diana from her car,
> And driven the hamadryad from the wood
> To seek shelter in some happier star?
> Hast thou not torn the naiad from her flood,
> . . . ."

The feeling that our present material progress is not really making for a richer life is expressed by many more. Even our own Lorado Taft, with a fine enthusiasm for beauty and an outstanding genius for creating it, is led by his observation to conclude that Americans are practically immune to the arts, have no joy in creating, and are not interested in the most important thing of all, the creation of an ideal civilization.

What answer have we engineer optimists to these critics?—

The good bishop sees but a small part of the picture and that not the bright and inspiring part. When the young Poe wrote his sonnet the Age of Electricity had not dawned. His hamadryads and naiads would today be quite at home with most of our scientists and engineers. And our gifted sculptor seems to feel that the progress made through technology expresses itself mainly in jazz. He fails apparently to see the poetry in the work of a Millikan, a Langmuir, a Steinmetz, or an Edison. He should see, as Pupin and others so clearly see, the idealism of the American machine.

The engineer with his enthusiasm over the human purpose of technology's accomplishments is guided by his ideal of a better living for man, but he keeps his feet on the ground in a practical effort to reach this goal step by step. He appreciates that

> "Heaven is not reached by a single bound;
> But we build the ladder by which we rise
> From the lowly earth to the vaulted skies,
> And we mount to its summit round by round."

The important thing is to be mounting the rounds. That we are moving onward and upward I for one firmly believe.

Is not one true indication of the direction in which we are moving found in the growing appreciation of beauty? The advertising pages of our magazines clearly show the turn of the tide. On every hand commercial competition seems to be along lines of greatest devotion to a beautiful product, and this is not confined to automobiles and bathroom fixtures. Art, which Henry James called "the shadow of humanity," is at last finding its place in industry.

The engineer accepts the line from Keat's famous Ode

> "Beauty is truth, truth beauty."

He is conscious of the beauty and the romance in many of the facts he deals with but he does not let his enthusiasm over the beauty, or his dreaming stirred by the romance, blind him to a proper weighing of the facts. Rather he develops from his dreaming a use of the facts for the further enrichment of life.

And what of the engineer of tomorrow? What thought are we giving to him? Engineers appreciate that by their example, as well as by their encouragement and active help given to educators and to the engineering novitiate, they are building the foundations of the profession more firmly and raising it ever higher. They know that education for useful living is not completed in college. It continues throughout life.

Our Institute, representing the electrical section of American engineers offers the fellowship of kindred souls, a broadening of outlook and of knowledge, a blending of humanism with technology. It carries inspiration to its members to be not only technicians of high order but also trained seekers of the needs of mankind, applying their skill and their knowledge to the end that life for the teeming millions of their fellowmen may be made more worth while, less burdensome, more healthful, and more noble.

Thus, my friends, do I conceive the true engineer,—one, who in thought and deed, is and ever will be a practical idealist.

Abridgment of

Safe Loading of Oil-Immersed Transformers

BY E. T. NORRIS[1]

Member, A. I. E. E.

Synopsis.—An attempt is made to describe simply and clearly the basis of the temperature rating of oil-immersed transformers and the relations between the temperatures measured in service, the maximum safe output rating, and the national standard ratings.

A description is given of an instrument for indicating the safe output rating of a transformer in service under any conditions of short time or continuous loading.

* * * * *

List of Symbols

A = Temperature of cooling medium—usually air or water.

D = Maximum variation in temperature of the circulating oil.

G = Maximum winding temperature difference.

Ga = Average winding temperature difference.

H = Hottest spot temperature.

h = $H - A$.

K = Constant.

N = Ratio copper to iron loss at full load.

P = Load on transformer as a fraction of full load.

R = Average temperature of the winding by resistance.

r = $R - A$.

T = Hottest oil temperature.

t = $T - A$.

As the load current in an oil-immersed transformer is increased, its temperature rises due to the increase in losses. One limit to the load which may be taken from a transformer is set, therefore, by the maximum temperature permissible.

Basis of Output Rating

The material most susceptible to damage by heat in a transformer is the insulation. The fundamental basis of the rating of the transformer is therefore the maximum temperature the insulation will safely withstand. The temperature of the hottest part of the insulation of the transformer (or the hottest spot temperature H) must never be allowed to exceed this safety limit.

The limit applies, of course, to the insulation both in the core and in the windings. Since, however, the core losses are practically constant for all loads whereas the copper or winding losses increase rapidly with the load, it is the winding insulation which is most affected by the loading, and its hottest spot temperature which determines the safe maximum load.

If it were possible to measure the hottest spot temperature while the transformer was in operation, it would be a simple matter to determine the maximum safe rating and to insure that it would not be exceeded. Unfortunately, except in a few special instances, there are no known practical means of measuring this temperature directly.

As a rule it is not possible to employ thermocouples or other forms of embedded temperature detector in such a way as not to weaken the transformer insulation and yet record accurately the true hottest spot temperature and be safe in operation. This position has recently been confirmed at a meeting of the International Electrotechnical Commission.

The most useful practical temperature measurements are:

a. The temperature of the hottest oil by thermometer = T.

This temperature is easily measured and a continuous record can be obtained while the transformer is in service. It however does not follow closely short-time load variations.

b. The average temperature R of the windings calculated from the resistance.

This measurement is mainly suitable under testing conditions. It is necessary to disconnect the transformer in order to measure the resistance, so that readings cannot be obtained during operation. The temperature measured is the average temperature of the whole winding.

To determine the maximum safe rating of a transformer from these two temperatures, it is necessary to know the relations between these temperatures and the hottest spot temperature.

Standard Output Ratings

It is important to distinguish between the true thermal rating of a transformer and its rating in accordance with a standard specification.

The true thermal rating is determined by the maximum safe hottest spot temperature. It is not a constant for a given transformer but may have any value depending on the conditions of loading and cooling.

The primary purpose of a national standard specification is to provide a basis for the comparison of transformers of different makes and types. The standard rating must be so defined that it can be determined easily and accurately in practise, and is therefore expressed in terms of the observable temperatures, R

1. Chief designer, Ferranti, Ltd., London, England.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

and T. It is based on certain definite loading and cooling conditions so as to be a constant for a given transformer.

The manner in which the observable temperatures R and T are derived from the hottest spot temperature for standardization purposes is explained in Pamphlet No. 1 of the A. I. E. E. Standards.

For the standards of three countries, typical values of these observable temperatures, after continuous rated load, are given in Table I. The standards specify both these limiting temperatures and state that neither may be exceeded.

TABLE I

Country	Self-cooling		Forced-cooling	
	R	T	R	T
U. S. A.	95	90	80	..
Britain	95	90	90	75
Germany	105	95	..	..

Typical values of the cooling medium temperature A, together with the resulting temperature rises, are given in Table II.

TABLE II

Country	Self-cooling			Forced-cooling		
	A	r	t	A	r	t
U. S. A.	40	55	50	25	55	..
Britain	40	55	50	25	65	50
Germany	35	70	60	..	..	..

The loading and cooling conditions chosen by all the standardization authorities are extreme. The British and American standards, for example, assume full load continuously, and an ambient air temperature of 40 deg. cent. continuously for self-cooled transformers—operating conditions which are rarely encountered in practise.

An apparent advantage of this basis is that the standard rating is very conservative and may safely be worked to in almost any climate and under any loading conditions.

It has become general practise for operating engineers to consider the standard rating as being the maximum safe rating under normal working conditions. Transformers much larger than necessary are therefore installed.

A relatively minor disadvantage of this position is waste in transformer plant installed and in exciting kv-a. and losses.

A more serious result is that operating experience cannot distinguish between transformers of good and bad thermal design. Undesirable opportunity is thereby given to the unskilled or unscrupulous manufacturer, and lessons of experience which are essential to progress in design and construction are lost to the industry.

It is suggested that the use of hottest spot temperature indicators be encouraged in standard specifications, that distinction be made between the true thermal rating and the standard rating as described earlier in the paper, and that alternative standard ratings be recognized covering more practical operating conditions.

Winding Thermal Conditions

A transformer winding with oil flowing through it is shown diagrammatically in Fig. 2. The temperature T of the oil leaving the windings is here assumed to be the same as the temperature of the hottest oil. This is so in most practical cases. Where the difference is appreciable, however, an average value can be assumed which will give sufficiently accurate results for the present purpose. The same conditions apply to the increase of oil temperature D.

The temperature of the oil at the bottom of the windings will be $(T - D)$.

The relation between the winding temperature at any point and the adjacent oil temperature depends largely upon which of the following conditions holds:

1. The direction of oil flow at right angles to the conductors in the winding.
2. The direction of oil flow parallel with the conductors in the winding.

Condition (1) applies to most core type and some shell type transformers.

Condition (2) applies to many shell type transformers.

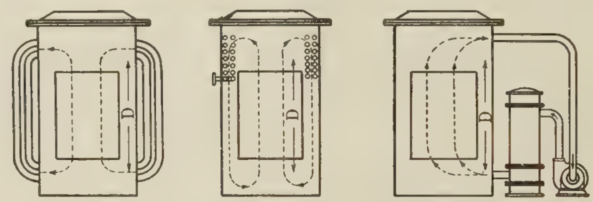

Fig. 1

Under condition (1), considering only a steady continuous load and assuming the windings are fairly symmetrical, the hottest spot temperature of the insulation at any point such as a or b in Fig. 1 will be a constant value G above the adjacent oil temperature. The hottest spot temperature of the copper, and therefore of the adjacent insulation at c, for example, will be $(T - D + G)$.

The hottest spot temperature H of the copper for the whole winding will be at some point b and such that

$$H = T + G \tag{1}$$

This temperature H must not exceed under any conditions of loading the safe limit; *e. g.*, 105 deg. cent. for I. E. C. rating.

Under condition (2), the thermal gradient in the winding in the direction of the conductors will be short-circuited by the copper, since the thermal conductivity of copper is approximately 2000 times that of the winding insulation. The temperature of the winding will be constant in the direction parallel to the flow of the oil. Then the winding temperature difference

will not be constant as in the previous case. At the top of the windings it will be $(H - T)$, and at the bottom, $(H - T + D)$. If G is the value at the top of the windings, then

$$H = T + G$$

as in Equation (**1**).

The temperature R measured by increase of resistance of the windings will be the average temperature of the copper in the windings taking the average in directions both normal and parallel to the flow of oil.

Under condition (1) its equivalent is the temperature of the copper at some point near the center of the winding such that:

$$R = T - K\,D + G_a \qquad (2)$$

For condition (2) the temperature of the copper is constant at all points in a vertical direction. Assuming G_a is the average value of the winding temperature difference at the top of the windings, then:

$$R = T + G_a \qquad (2a)$$

Comparison of this relation with Equation (**2**) shows

Fig. 2

that if the flow of oil is parallel to the conductors, K becomes zero.

It should be noted, however, that in practise, the direction of oil flow cannot be parallel to the conductors for the whole of the winding. The temperature relations for condition (2) will therefore apply to only part of the winding, and for all types of transformers K will be greater than zero.

It is now possible to estimate the affect on the permissible loading of variations in the temperature of the cooling medium. The method can be most clearly shown by an example.

Consider an A. I. E. E. rated self-cooled transformer with the following thermal characteristics after continuous full load with an ambient air temperature of 40 deg. cent. These values are typical of a medium sized self-cooled core type transformer.

$R = 95 \quad D = 20 \quad G_a = 18 \quad G = 20$

$T = 85 \quad H = 105 \quad K = 0.4$

Ratio of copper to iron losses $= N = 2$

Equation (**2**) becomes $95 = 85 - 8 + 18 \qquad (7)$

Equation (**1**) becomes $105 = 85 + 20$

Suppose the ambient temperature is only 25 deg. cent. At full load $R = 80$ deg. cent., $T = 70$ deg. cent., and $H = 90$ deg. cent. The load may safely be increased until H is raised to 105 deg. cent.; *i. e.*, h may increase to 80 deg. cent.

Let P = the new permissible load as a fraction of normal full load

The new total losses will be $\dfrac{P^2 N + 1}{N + 1}$ times normal.

The new copper losses will be P^2 times normal.

Equation (**4**) becomes:

$$80 = \frac{2\,P^2 + 1}{3} \times 45 + 20\,P^2$$

whence $P = 1.14$

Hence the effect of reducing the ambient temperature from 40 deg. cent. to 25 deg. cent. is to increase the output rating of the transformer 14 per cent.

At this overload, with an air temperature of 25 deg. cent., the hottest spot temperature will be 105 deg. cent. and Equation (**2**) will read

$$92.8 = 79 - 9.6 + 23.4 \qquad (8)$$

It is instructive to compare (**7**) and (**8**). Both the hottest oil and winding temperatures are lower in the second case, but the transformer is equally loaded thermally in the two cases.

The formulas developed in this paper are intended for purposes of illustration and exposition rather than for actual application to practical problems.

The predetermination of the true thermal rating of transformers requires numerous formulas to cover the wide range of loading and cooling conditions that may occur in practise. None of these formulas would be sufficiently general to be suited to the present purpose. The complete subject has been treated recently by the present author.[2]

Relation Between Oil Temperature and Output Rating

The hottest oil temperature is easily measured on a transformer in service, and it is well, therefore, to examine whatever information as to the loading conditions can be obtained from it.

From Equation (**10**) $P = \sqrt{\dfrac{H - T}{G_n}}$ where H and T are values at load P, and G_n is the winding temperature difference at normal load.

In the example $G_n = 20$

Hence $P = \sqrt{\dfrac{105 - T}{20}}$

This relation is plotted in a curve in Fig. 4. The practical use of the curve has been pointed out by

2. "Thermal Rating of Transformers," *I. E. E. Journal* (England), Vol. 66, No. 380, p. 841.

G. L. Porter. It gives the maximum oil temperatures for different loads. If, for instance, in the example the load is 120 per cent, the oil temperature must not be allowed to exceed 76.2 deg. cent. Whether the transformer is able to carry this load continuously depends on the air temperature. Equation (**9**), or Fig. 3, shows that for this to be possible, the ambient temperature must not exceed 18 deg. cent.

The curve may be applied to temporary overloads as well as to continuous loads. For instance, an overload of 30 per cent in the example may be applied until such time as the oil temperature reaches 71.2 deg. cent.; and this is true no matter what the previous loading conditions, if within the safe rating; *e. g.*, whether the transformer has previously been on full normal load or even on no-load.

If the air temperature is greater than 5.5 deg. cent. (Equation (**9**) or Fig. 3), it is only a matter of time before the oil temperature reaches 71 deg. cent. When this happens, the load must be reduced. This use of Equation (**10**) gives results slightly on the safe side for short time heavy overloads of only a few minutes' duration, since it makes no allowance for the thermal time constant of the windings.

Again, suppose at a given instant, the oil temperature

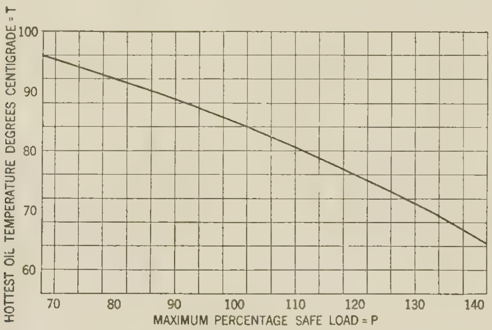

Fig. 4

of this transformer is 75 deg. cent. but the previous loading history is unknown; the curve states that any load up to 122 per cent may safely be taken from the transformer. (Actually some margin should be allowed here and a somewhat lower limit than 122 per cent assumed). How long this load could be taken depends upon the air temperature, but always so long as the oil temperature does not exceed 75 deg. cent.

The curve also shows up the possible danger of oil temperature alarm protection. Suppose, in the example, the oil thermometer were set to operate an alarm when the hottest oil temperature exceeded 80 deg. cent, Curve 4 shows that the alarm would be given quite unnecessarily so long as the load were below 112 per cent. On the other hand, the transformer might be carrying a load greater than 112 per cent and greater than the maximum safe limit (*i. e.*, with a hottest spot greater than 105) without the alarm functioning.

In some countries, it is common for oil alarms to be set at 90 deg. cent. In the example referred to, representing an average oil-immersed self-cooled transformer, if the air temperature were 30 deg. cent. and the transformer were overloaded 20 per cent continuously, the hottest oil rise would be 58.2 deg. cent. and the hottest oil temperature 88.2 deg. cent. The alarm would therefore not function, although the hottest spot temperature would be 117 deg. cent. and the transformer loaded beyond the safe limit.

These illustrations show the numerous practical uses of a curve such as Fig. 4.

Transformer Safe Load Indicator

It has been shown that the hottest oil temperature is misleading as a guide to the safe loading of a transformer and that the true criterion is the hottest spot temperature within the windings. Instruments for measuring indirectly this hottest spot temperature have been developed in various forms by many transformer manufacturers.

In principle, the components T and G from Equation (**1**) are measured separately. T is measured directly and G is obtained indirectly through the relation between it and the load current in the windings. A current transformer is therefore necessary and may be connected on either primary or secondary side of the main transformer.

Such instruments show clearly whether the transformer is fully loaded and will actuate an alarm or close a relay tripping circuit when a dangerous condition is being approached.

By calibrating an instrument of this type in percentage of maximum safe load instead of in hottest spot temperature, the information given by the curve Fig. 4 and illustrated by the examples previously described can be indicated directly. Inspection of Equation (**10**) shows that the variable factors are P, the load on the transformer, and T, the hottest oil temperature, both of which are already used in the hottest spot temperature indicator.

With this calibration the instrument shows directly:

1. The existing load as a percentage of the maximum safe load—showing how much of the permissible output rating is being utilized.

2. The maximum load on the transformer during any desired period expressed as a percentage of the maximum safe loading. If, for instance, this record were 75 per cent over a period of 24 hr., it would mean that at no time during that period did the load on the transformer exceed 75 per cent of its available capacity.

The formula assumes that when any given load is switched on, the winding temperature difference G reaches the value corresponding to that load immediately. This assumption underestimates the overload capacity of the transformer by a few minutes' duration of load. This is a desirable characteristic, in that for rapid and dangerous increases in load, warning will be given a short time before the danger point is actually reached.

Since the standard rating of a transformer is based

on continuous loading and on an abnormally high cooling medium temperature, the true rating under the normal operating conditions of discontinuous loading and comparatively low cooling medium temperature will be considerably greater than the standard rating.

By means of the safe load indicator, the true thermal rating under operating conditions may be fully utilized, and a corresponding saving made in capital cost of transformer plant installed and in exciting kv-a. and losses.

Abridgment of

Analytical Determination of Magnetic Fields

Simple Cases of Conductors in Slots

B. L. ROBERTSON* and I. A. TERRY†

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—*In this paper, La Place's and Poisson's equations are applied to cases of current-carrying conductors in rectangular slots to show the flux distributions which obtain.*

The paper first treats with the general case which is a single conductor, completely surrounded by insulation, at the bottom of a slot. Next is taken up the more practical case of a slot containing two insulated conductors, one above the other, in which currents of equal magnitude are considered first to flow in the same direction, and then in opposite directions.

In addition to these analyses, a few special cases are discussed. Methods by which the flux distributions in slots containing an even number of coil sides may be obtained, or in slots the conductors of which carry currents not in time-phase, are also discussed. Equations are developed from which all of these fields can be calculated.

A discussion is included to show the distribution of flux on the assumption that the lines go straight across the slot, and a comparison is made between the slot inductance determined mathematically from the equations developed and by the usual design formulas. In the case considered it is found that the design formulas give a value of slot inductance which is about 96 per cent of that obtained by the mathematical treatment, which is within limits of engineering accuracy. An expression is developed which shows the error that may be expected in any particular case.

* * * * *

I. Introduction

WITHIN the last few years several papers have been presented before the Institute, and articles have been published in various technical journals on the theory and practical applications of flux plotting. It has been shown that if they are devoid of current, quite accurate flux plots can readily be made free hand for many geometrical figures, about the only fundamental requirement being a knowledge of the potential difference between the various boundaries of the configuration. Although the problem is greatly complicated in current-carrying regions, methods have been outlined for free-hand mapping of fields under these conditions, and can be applied very well whenever the general arrangement of the lines of force is known in advance. If the general field arrangement is unknown, then a great deal of sketching and resketching must be done in order to obtain a correct plot; and often much labor can be saved by deriving, analytically, the equations for the lines of force and then plotting the loci of these equations.

Several years ago, W. Rogowski solved La Place's and Poisson's equations for the case of a pancake type of transformer, analytically determining the magnetic field distribution about the windings. An excellent translation of Rogowski's work was given by Doctor A. R. Stevenson, Jr.,[1] in 1926. Shortly after that, Messrs. Stevenson and Park[2] showed the application of the analytical method of determining the flux distribution about the field pole of a definite pole machine, including in their discussion several other figures which are of theoretical interest. Cases of conductors in slots have also been treated with,[3] but there the solution results in a series which converges so slowly that the task of plotting the field is laborious.

In this paper, analytical expressions are developed for plotting the flux about rectangular conductors in rectangular slots by use of the method originally employed by Rogowski. Flux plots are shown for a number of different locations of a single conductor in a slot, and for the practical case of two conductors, one above the other in the same slot. The mathematical expressions are in the form of a series that converges very rapidly, thus simplifying the problem of making the plots.

In addition to the above, a comparison is made between the slot inductance determined (a) by the usual design formulas, (b) by mechanically integrating the mathematical flux plot to obtain the flux linkages, and (c) directly from the R-equations.

From the latter, a simple expression is obtained for use in design formulas to give the increase in induc-

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Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

1. Reference at end of paper.
2. See reference (2).
3. See reference (5).

tance due to the curvature of the flux lines over the inductance determined on the usual assumption that the lines of force are everywhere parallel to the bottom of the slot.

II. Fundamental Equations

As a general example, in Fig. 1, which represents an insulated rectangular conductor at the bottom of an infinitely deep slot, it is assumed that:

1. The permeability of the air, insulation, and copper is unity.
2. The permeability of the iron is infinite. (These two assumptions mean that the flux must enter the iron at right angles to the surface).
3. The conductors are subdivided, thus eliminating skin effects and resulting in uniform current density.

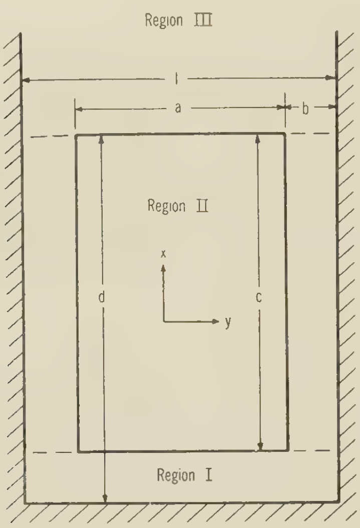

Fig. 1—General Case of Conductor Completely Insulated from Slot

Rogowski developed the conception of dividing the slot into regions, satisfying either LaPlace's or Poisson's equations; then, by considering each region separately, the current distribution may be represented by a single dimension Fourier series, and the problem greatly simplified.* The single dimensional Fourier series may be chosen to represent the current in the one slot only, but another simplification is made possible from the application of the method of images.

It is well known that with a conductor near an iron surface of infinite permeability it is possible to replace the iron surface by a conductor, called the image of the first, carrying current in the same direction. Similarly, a slot may be replaced by its image on both sides and below, (see Fig. 2), the first group of images being re-imaged, etc. Due to the fact that the slot is open at the top only a double row of images exists, which then replaces the original conductor and slot, and gives rise to a periodic reactangular current distribution, the Fourier series of which can readily be obtained.

*Herein lies the main difference between the present analysis and that of E. Roth, (reference 5), who used a two dimensional. Fourier Series.

The total field of the slot of Fig. 1 is divided into three distinct regions:

Region I. Air district between the images formed by the bottom of the slots and the bottom of the conductors.

Region II. District occupied by the conductors in a horizontal row including the air or insulation spaces between the conductors.

Region III. The air and insulation space above the conductors.

Region I, having no currents, satisfies LaPlace's equation,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = 0 \tag{1}$$

Region II, being a district of currents, must satisfy Poisson's equation,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = - 4 \pi I \tag{2}$$

VI. Slot with Two Conductors

The slot containing two conductors, completely insulated from each other and from the iron walls of the slot and placed one above the other, is typical of synchronous machine design and therefore forms one of the most practical application of flux plotting by the mathematical method.

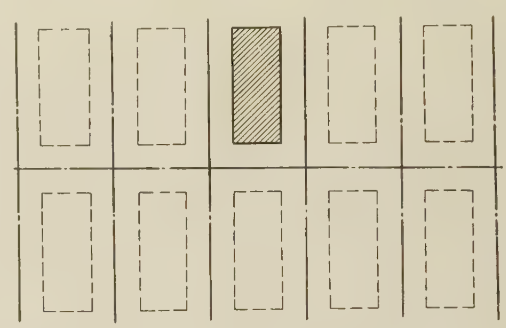

Fig. 2—Images of a Current Carrying Conductor in an Infinitely Deep Slot in Iron

In the solution of this problem, the entire field is divided into five regions, (Fig. 12). The air regions satisfy LaPlace's equation, Equation (1), and the current carrying regions satisfy Poisson's equation, Equation (2).

In the general case previously discussed, it is obvious that the magnetic field for the single conductor in any certain configuration will always yield one type of plot. Its form will be altered only by slot and copper dimensions, but will not be affected by the magnitude of the current. The direction of flow of the current will, of course, change the direction of the lines of flux.

The solution of this problem, however, brings into

consideration the direction of the flow of current in the conductors; that is, whether or not the current in the upper coil side is flowing in the same direction as the current in the lower coil side. Furthermore, the relative magnitudes of these currents are important

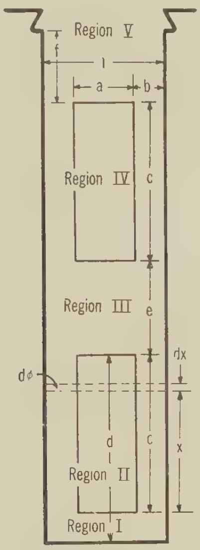

FIG. 12—SLOT WITH TWO CONDUCTORS

because for each ratio of the two densities there exists a distinct field. An infinity of flux plots is thus the complete answer to the problem. Although any one of these plots can be determined accurately, it is within the scope of this paper to discuss fully only two important types, and to indicate the solution for any other set-up.

The illustration first treated here is that in which the two conductors carry equal currents in the same direction. Similar to that shown in Fig. 2, the current-carrying regions will now be represented by two infinite series of reflected and re-reflected images, one above the other. Each region has its own Fourier series for the current density, and since the density is the same for each group of images, the Fourier series is the same for each region and is of the form given by Equation (**8**).

The form of the function R is as it was before, and from its substitution in Equations (**1**) and (**2**) are obtained the two sets of relations given by Equations (**1b**) and (**2b**). The first set of relations now holds for Regions I, III, and V, since they carry no current, while the second group holds for Regions II and IV, the current-carrying districts. The general solutions for R and the constants for these equations are obtained in like manner to the ones detailed in Section II of the paper. It is necessary now to solve simultaneously the five sets of regional solutions in order to determine the coefficients A_0, A_n, . . . etc. The reader is referred to Appendix D for the complete mathematical analysis.

The numbers to the right of Fig. 13 were obtained by calculating the flux on the basis that it crosses the slot in straight lines. It makes little difference in the values of total flux above the lower conductor, as indicated by the results.

The case in which the conductors carry equal currents, but flowing in the opposite direction, is considered next. Whereas both currents in the previous illustration were flowing in a negative direction,—that is, up out of the figure,—the upper current will now be assumed to flow positively. Within this reversed current district, Region IV, Equation (**2**) must be altered to read,

$$\frac{\partial^2 R}{\partial x^2} + \frac{\partial^2 R}{\partial y^2} = + 4 \pi I \qquad (\mathbf{17})$$

f I, the current density expressed as a Fourier series, is to be the same as it was before. If, however, I is changed in sign, then Equation (**2**) still will hold. The final regional expression for the upper conductor contains a change of sign before the term including α_n. Such a condition calls for a new determination of all of the coefficients in the regional equations because these relations must be solved simultaneously. The analysis for this case is given in Appendix E.

Fig. 14 illustrates the field about the same two conductors of Fig. 12, the upper current now being reversed. At the bottom of the slot, and well up the sides, the flux plot is practically dependent only on the lower conductor because of the extremely weak field in that region produced by the reversed current above. With-

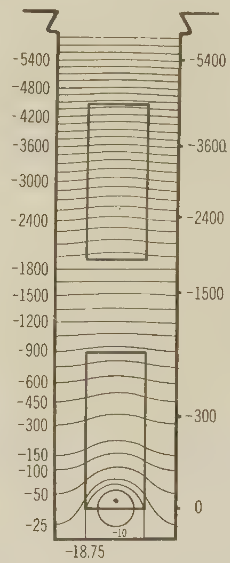

FIG. 13—FIELD ABOUT A TWO-CONDUCTOR SLOT
Currents in the conductors equal and in the same direction

in the upper copper, however, the lines rapidly change their shape, eventually closing within the slot about a second kernel.

Fig. 15 shows in detail the field about the second kernel. Immediately about the kernel the flux travels in approximately elliptical paths, the outer approaching the slot walls and closing upon themselves at very

great distances. Beyond this group of lines the flux strikes the sides of the slot. These plots verify those determined graphically by Calvert and Harrison.[4]

Flux plots for armature slots of a synchronous machine are necessarily dependent upon instantaneous values of current, except for pull-pitch coils. In these instances, the currents in the conductors bear a constant relation to each other. The field plot will then have the same conformation although a changing magnitude of total flux. In actual practise, full-pitch windings

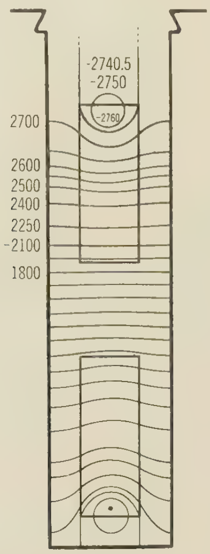

Fig. 14—Field About a Two-Conductor Slot
Currents in the conductors equal but in opposite directions

are seldom used, the usual design being somewhere near $\frac{2}{3}$-pitch armature coils. The currents in the upper and lower conductors now differ in time-phase,

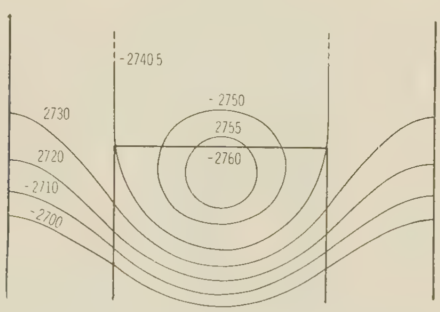

Fig. 15—Detailed Field Showing Whirl of Flux about Top of Upper Conductor of Fig. 14

and for each instant of time there corresponds a new flux plot.

The method by which a field map may be made for any ratio of conductor currents is very simply outlined. The only important step is to adjust the signs of the Fourier series for the current densities of Regions II and IV. For currents in the same direction both series will have the same sign which will depend upon the direction of the current flow. For opposite currents the series will then of course have opposite signs. Substitution of these current density forms in the regional equations will automatically care for all algebraic signs which follow.

VII. Inductance Comparison

One of the most important applications of flux plotting is the determination of the inductance of a current-carrying system. To illustrate the method, the inductance of the conductors in the slot under consideration has been determined. In a paper recently presented to the Institute by Mr. P. L. Alger,[5] a very complete discussion was presented on the leakage reactance of the armature winding of a synchronous machine. In his paper, slot-leakage inductance is calculated by assuming that the flux lines in the slot

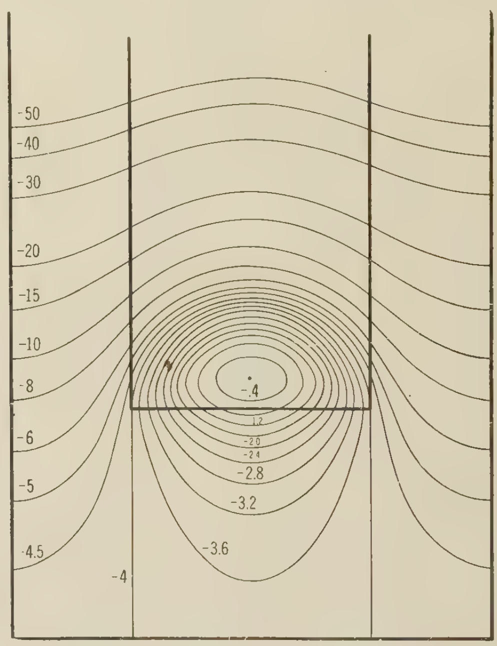

Fig. 17—Detailed Field of a Conductor Showing Whirl of Flux about Kernel

go straight across. This, of course, involves an error because the curvature of the lines as seen in the plot of Fig. 13 is such that a given flux will link more current than if the flux goes straight across the slot; therefore, the exact method will give a larger reactance. However, the amount of error due to the approximation will be seen to be so small as to be negligible. The reader is referred to Appendix E for the derivations of the inductance formulas.

The following tabulation shows the various components of inductance as determined graphically, by mechanical integrating the flux plot, and analytically, under the assumption that the flux lines go straight across the slot. This analysis has been carried only to the bottom of the wedge, (Fig. 12).

4. Reference (4).

5. Reference (3.)

Region	Inductance in (Abhenrys)/N^2	
	Present approximations	Mechanical integration of Fig. 13
II	0.150	0.138
III	0.250	0.250
IV	1.005	0.950
V	0.758	0.753
	2.163	2.091

This comparison shows an increase of approximately 3.5 per cent in the inductance determined from the mathematical flux plot. Such an increase is very reasonable, since the assumption that the flux lines go straight across the slot is in error to some extent in regions near the bottom of the slot. This is shown in the figure, the values on the outside of the slot indicating the flux determined on this basis.

In Appendix G the inductance of the two conductor slot is determined mathamatically from the vector potential R. The expression therein derived shows directly the magnitude of the correction term which gives the increase of inductance due to the curvature of the flux lines above the inductance calculated on the assumption that the lines of flux go straight across the slot. By the omission of insignificant terms the correction term becomes

$$L' = \frac{l^3}{c^2\, a^2\, \pi^3}\left(c - \frac{l}{2\,\pi}\right)\sin^2\frac{a\,\pi}{l}\, 10^{-9} \text{ henrys per } N^2 \tag{18}$$

This is simple enough for use in design formula wherever it affects the accuracy to an appreciable extent.

For the slot of Fig. 13.

$$L' = 0.087 \times 10^{-9} \text{ henrys per } N^2$$

or an increase over that obtained by Equation (**12f**) of about 4.1 per cent.

This agrees with the increase in inductance obtained from the flux plot, being slightly higher because the mechanical integration of the flux plot is limited to finite increments whereas the mathematical method deals with infinitesinal increments.

VIII. Detailed Plots

The flux plot of Fig. 17 has been made for general interest, to show in detail the field about the kernel of a conductor. The distance between the lower face of the conductor and the slot bottom was made great enough to bring out the whirl of flux in a pronounced manner.

Summary

The usual types of rectangular slots met in practise have been considered, and the general method of attack has been given in sufficient detail to make its application to other examples quite clear and straightforward. The general equations will have been developed may be applied to any slot by simply substituting for the particular dimensions involved.

The error in inductance calculated on the assumption that the flux tubes go straight across the slot has been shown to be small enough to be negligible in usual slots met in practise, thereby indicating that present assumptions give sufficiently accurate results for engineering purposes.

Acknowledgments

The authors wish to express their appreciation to L. P. Shildneck for the development of Appendix A of the paper, to Doctor E. J. Berg of Union College for his kindness in reviewing the manuscript and offering valuable comments, and to Mr. R. E. Doherty for his helpful suggestions.

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ENGINEERING SOCIETIES EMPLOYMENT SERVICE

EXCERPTS FROM LETTERS OF APPRECIATION

April 29, 1929.

Please find enclosed a check .... as a payment to the Engineering Societies Employment Service for its prompt and efficient service in placing me with the .... corporation. I was accepted immediately upon the first interview.

January 5, 1928.

We have engaged two previous men sent from your Department and returned the cards to your office. So far these men are working out satisfactorily and we wish to thank you for your helpful interest.

January 3, 1928.

It is unfortunate but true that most of your applicants are of a much better grade than we can use at the present time.

We wish to thank you for your kind and efficient attention to our request for men and are returning to you such applications as were sent to us for our approval.

August 9, 1928.

Just a note to thank you for your letter of yesterday with the attached records of 1928 electrical engineers. Our transmission Engineers will go over these today, after which I shall communicate with you, returning the records to you at that time.

We appreciate not only what you have done, but the fine spirit with which you did it.

Abridgment of

Telephone Transmission Networks

Types and Problems of Design

BY T. E. SHEA[1] and C. E. LANE[1]

Associate, A. I. E. E. Associate, A. I. E. E.

Synopsis.—A brief résumé of the nature of telephonic signals is given, showing how the qualities of wave composition which distinguish signals from other electrical waves set the requirements on networks and provide a basis for their design.

The principal functions of wave filters, equalizers, telephone transformers, line balancing networks, and artificial lines are outlined. In order that these networks may be used in conjunction with other apparatus in the telephone system, they must provide efficient transmission, low distortion, good impedance balance, stoppage of longitudinal currents, stable characteristics with current variations, low external coupling, and low reflection coefficient. In addition to these requirements, the network must not cross-talk into associated circuits and must have desirable impedance characteristics in the attenuation range of frequencies as well as throughout the transmission range.

An illustration of the use of transmission networks in a typical three-channel carrier telephone system is given describing the functions of the line filter sets, the directional filter sets, band filters, and equalizers.

Some of the engineering limitations on the design and construction of networks are discussed.

* * * * *

THE past 30 years have witnessed many important developments in electrical communication. Looking back, it appears almost as though the various dynamic sciences which had rapidly grown in scope under influence of Maxwell, Helmholts, and others, having been for a time pent up, were fairly bursting in their eagerness to spill over into the communication field innumerable facts capable of being put to great practical use. The writings of Heaviside are clear evidence of the transition, pointing to many useful relationships while making important advances in electrodynamics.

Subsequently, striking applications of the new knowledge as typified by inventions and discoveries went constantly hand in hand with a codification or systematization of the knowledge found useful. Thus, paralleling the origination of the loading coil by Pupin, the thermionic vacuum tube by De Forest, and the wave filter by Campbell has been the systematizing work of Campbell, Kennelly, Blackwell, and others. Out of the latter process has grown what is often called "telephone transmission theory." One of the most important and striking branches of "telephone transmission theory" is that which relates to the properties of electrical networks used for transmission purposes, and called *transmission networks*.

Space is not available here to enter into a complete discussion of the uses to which transmission networks are put, and for purposes of illustrating such uses, we may confine ourselves to largely to certain aspects of long distance telephony. This choice of illustration will serve perhaps better than any other to bring out the physical and economic attractions which the networks can have for engineers.

Long distance circuits are of various kinds. There are open wire,[2] cable, and radio facilities. These impose very different requirements on apparatus used in transmission. From an electrical standpoint, they may provide telegraph, normal telephone (both side circuit and phantom circuit),[3] superimposed carrier current (telephone and telegraph), telephotograph, and radiotelephone transmission.

The length of the circuits, together with the high standards of transmission they require, and the desirability of employing them intensively by multiplexing messages, means careful consideration of the fundamental factors influencing transmission and of the numerous functional objectives which component apparatus must attain. This is particularly so if the service provided is to have universal standards, regularity of operation, and low costs of maintenance and operation.

With this situation in mind, we may consider in some detail just what the manifold functions of typical networks are. The functions necessarily divide themselves according to what they have to do (1) with the primary purposes of employing the networks, and (2) with the conditions to be met by networks as integral

1. Both of the Bell Telephone Laboratories, New York, N. Y.

Presented at the Regional Meeting of the South West District No. 7, of the A. I. E. E., Dallas, Texas, May 7-9, 1929. Complete copies upon request.

2. *Open-wire facilities* are those whose circuits employ wires separately strung overhead on pole lines, in contrast to *cable facilities* which use wires from among those provided by a cable. The electrical characteristics of the two types of circuits are generally quite different.

3. *Normal telephone transmission* is that which uses directly the ordinary frequencies of speech and music. In carrier-current transmission, a modulation is employed in order to permit using a different range of frequencies for transmission purposes. (See Section 4.)

A phantom circuit is one which straddles two pairs of wires, one pair acting as a conductor in either direction. In this case, each pair is also used for transmission in which one wire of the pair works in one direction and one in the other. Each of the pairs is said to comprise a side circuit and to afford side circuit transmission.

parts of systems, working harmoniously with other apparatus. As a prerequisite to such a discussion we shall start with a survey of the ideals of signal transmission.

Only the more important types of transmission networks will be mentioned. These are; *wave filters, equalizers, telephone transformers, line balancing* (*i. e., simulating*) *networks*, and *artificial lines*.

I. Signals and Their Transmission

Signals, whether of systems of telephony (carrying speech and music), telegraphy, or telephotography have qualities of wave composition which differentiate them from other electrical waves. These qualities determined largely the performance required of networks which aid in their transmission, and thus provide much of the physical basis of transmission network design methods. From the purpose and circumstances of signals, it is obvious that they are essentially of a *temporary* character. They are used at a particular time to convey information and they cease as soon as their message has been transmitted. We may consider as pertinent examples of this, articulate speech, music, and telegraph signals.

Consequently, even the most elementary of signals, such as a "single-frequency tone," maintains an approximate steady state merely for a limited period. Such elementary signals can be used to convey only a very small number of different ideas. For the free interchange of ideas through signals, we must employ either a complex code of artificial groups of signal elements to represent the characters of a written language, or the much more complex signal elements (vowels, consonants, and notes) required in spoken language and music.[4] Because of economic considerations, in the case of telegraphic signals, the duration of pulses and time between is made so short that the transient state predominates, so that the distinguishing characteristics are largely transient in character. In the case of speech and music, owing to changes in expression much of the distinguishing characteristics are also transient in character. To put it another way, the envelopes of the waves *modulate with time* the characteristic frequencies which the sounds, if sustained, would tend to possess, and have an important bearing on the meaning conveyed by the signal. Preservation of these envelopes is a matter of transient state transmission. But transient states really involve the transmission of steady state frequencies grouped as *continuous bands* along the frequency scale. *Preservation of the entire content of a signal therefore involves consideration of the transient properties of networks; i. e., involves their steady-state properties over a somewhat w ide frequncy range.*

4. The signals corresponding to pictures resolved for transmission purposes are somewhat similar in form to telephone and telegraph signals. On the other hand, depending on the speed at which they are sent, they may require the use of a frequency range greater even than that of speech or music.

In connection with this section see "Transmission of Information," by R. V. L. Hartley in the *Bell System Tech. Journal*, July, 1928.

The imperfections which may creep into the transmission of signals may be classified under three headings: improper signal *volume, distortion* of signal content, and *interference* by waves foreign to the signals; that is, if waves are received of appropriate intensity, if the important frequency ranges are uniformly transmitted, and if nothing but the desired waves are received, the ideals of transmission will have been realized. Waves may be so strong as to cause physiological difficulties in reception, or so weak as not to be recognized. This means that efficiency of transmission is an important factor although, when amplifiers are used, partly an economic one. Signal distortion is of two kinds—*amplitude distortion* and *phase distortion.* Amplitude distortion arises from the transmission of different frequencies with unequal efficiencies and is highly important in all types of signals, but its aggregate importance depends on the importance of the frequency components that are efficiently transmitted. Phase distortion results from different frequencies traveling with different velocities such that their relative arrival times differ from their relative starting times. It is ordinarily less important in the transmission of speech than in other kinds, but the accumulation of phase distortion which may occur on long telephone circuits gives rise to undesirable transient effects. Interference may be of two kinds: It may arise from the introduction of energy into the communication circuit from outside, through electrostatic or electromagnetic coupling, or it may result from the imperfect separation of several simultaneously transmitted signals or from the generation of extraneous frequency components through modulation.

These three types of imperfections should be kept in mind in considering the functions of different types of transmission networks.

II. Principal Functions of Transmission Networks

The principal functions of the more important types of networks may be described as follows:

Wave Filters

It is characteristic of telephonic signals that their transmission requires the use of a continuous band of frequencies whose width may be perhaps 2000 cycles as a minimum and 6000 cycles as a maximum (both approximate). Where, as an example, due to economic factors it is desirable to transmit simultaneously two or more telephonic frequency bands, whether this be done entirely conductively along wires or partly by radiation through space, discriminating means are required to make the transmission of a particular communication channel efficient to that band, or those bands, of frequencies which are desired, while rendering the circuit highly inefficient at other frequencies. To put this in

another way, means are required which will *pass freely* desired bands of frequencies, while *highly attenuating* or extinguishing neighboring undesired bands of frequencies. This is the essential function which the wave filter serves.

Equalizers

In any telephonic signal which is to be transmitted efficiently, proper audition requires that all component frequencies be treated alike, in so far as efficiency of transmission is concerned, in order that some frequencies may not be unduly emphasized to the detriment of others. This uniformity of efficiency of a band of frequencies is required, of course, primarily as a characteristic of the over-all system traversed by the signal. Some parts of a transmission system are inherently not capable of closely uniform transmission. For example, unloaded lines have an attenuation which rises gradually with frequency. The equalizer cannot restore the loss of effectiveness which occurs to some frequency components due to such distortion. Amplification of power requires such generative devices as vacuum tubes. What the equalizer can do is to attenuate efficiently transmitted frequencies in such a manner and to such an extent that all desired frequencies suffer or prosper in transmission alike.

Telephone Transformers

Efficiency of transmission in telephone circuits is governed largely by "matching of impedances" at junction points in a circuit. This is the chief purpose of telephone transformers. Because of the relatively high frequencies employed in telephone work and because a rather wide band of frequencies needs to be transmitted, inherent internal impedances, such as those of winding capacities, become very important and require that the telephone transformer be considered primarily as a network. In the case of transformers working into the very high input impedances of vacuum tubes or providing band transmission at high frequencies, we may say that the frequency range of transmission and the transformation ratio of telephone transformers is as completely dependent upon the magnitude of inductance and capacity elements as are the characteristics of wave filters.

Line Balancing Networks

The two-way repeater circuit has essentially the form of an a-c. bridge in which a balanced condition depends upon both the similarity of certain transformer (hybrid coil) windings and the equality of impedance of the two halves of the repeater output circuit. In the case of the 21-type (two-way, one-amplifier) repeater, the two halves are the telephone lines joined by the repeater. In the case of the more stable 22-type (two-way, two-amplifier) repeater, an output circuit exists at each end of the repeater and each telephone line is matched in impedance against a "dummy" line, or balancing network. The function of this network is solely to present the same impedance to the repeater over a range of frequencies as is presented by the line; *i. e.*, to simulate the impedance of the line. No *through* transmission is required of it. The design of such networks involves a choice of configurations of resistances, capacities, and inductances which bear a close physical relationship to such impedance elements of the line as dominate its total impedance, and a determination of impedance values of the network elements in accordance with network theory.

Artificial Lines

The function of artificial lines is to exhibit some transmission property, or properties, of a real line, at one frequency or over a range of frequencies, so that there may be compactly constructed a network which will serve for certain purposes involving wave propagation, in place of a real continuous line. The artificial line is generally a network of lumped, discrete impedance elements, whose constants are computed from network theory. One of the most common forms of artificial line is the variable *attenuator*, which is used as a basis of comparison in attenuation and transmission loss measurements. It is usually constructed of resistances so that over a wide range of frequencies it displays uniform attenuation. Other forms of artificial line, however, over a range of frequencies display the varying attenuation (and perhaps phase) properties of real lines and circuits and involve properly disposed inductance, capacity, and resistance units. In contrast to the equalizer, they simulate, rather than compensate for, frequency-transmission characteristics.

III. Secondary Functions of Transmission Networks

The functions of transmission networks outlined in Section 2 show the ordinary reasons for their employment in communication systems. When so employed, however, since they must fit into the transmission scheme of systems and work harmoniously with other apparatus, they may be faced with numerous additional requirements. Occasionally, the latter duties may even provide the more difficult design requirements. The more important of these possible secondary requirements follow:

Efficient Transmission

This requirement applies particularly to transformers, wave filters, and equalizers. Each of these types of apparatus could fulfill its principal duties while consuming an *undue portion* of the strength of signals entrusted to it. Under some conditions, amplification of signals by the use of vacuum tubes could offset this consumption from a transmission standpoint at an economic sacrifice, and the problem would then be one of economic balance; but in other cases the amplification would be objectionable because accompanied by such factors as amplification of noise, impoverishment of circuit balance, and loss of circuit flexibility. Efficient transmission is secured by proportioning materials so as to limit dissipation of energy.

Low Distortion

It is not possible, of course, to secure entirely uniform transmission of all signal frequencies; and, indeed, refinements of transmission in this direction beyond a certain point have economic limits. The quality of signals is impaired, however, to the extent that distortion exists. When distortion is excessive, equalizers often provide a desirable way of reducing it, but do so at a sacrifice in over-all circuit efficiency.

Impedance Balance

There is a number of kinds of impedance balance commonly found in communication circuits. All of them are akin to balances in a-c. bridge circuits. They need to be maintained over bands of frequencies. Balancing arrangements offer a kind of selectivity which differs from filter selectivity in that in general it keeps apart throughout systems two trains of waves arising from different sources and drawn off to different destinations, instead of separating on a basis of frequency difference waves which have mingled in a common circuit. An example is the balance necessary in a side-circuit, and therefore imposed on transformers or filters located in the latter, in order that currents traveling a superimposed phantom circuit may not interfere with side-circuit transmission. A second kind of balance is the repeater balance mentioned in Section 2, which may lead to requirements on, say, filters located in the output circuits. Here the separation is between incoming and outgoing speech signals using the same frequency range. In other cases, circuit balance is relied upon to prevent interference currents set up between circuit wires and ground from entering the circuit of the former. To obtain a high degree of balance, apparatus located in a balanced circuit must be quite symmetrical in its circuit impedances with respect to the associated circuit from which it is protected by balancing.

Stoppage of Longitudinal Currents

Longitudinal currents are those which travel both sides of a circuit in the same direction as parallel paths and return by some other path, generally a ground circuit. They are objectionable because (1) they tend to enter the transmission circuit whose sides they travel,—in this case called a transverse circuit—through irregularities of balance in the latter, and to unite with transverse currents; and (2) in many cases they correspond to objectionable voltages of considerable strength. They may be eliminated in two ways; (1) by providing for them a short-circuit path to ground in the longitudinal circuit, and (2) by causing virtually an open-circuit gap to occur in the longitudinal circuit, each of the methods being so employed as not to affect transmission in the transverse circuit. Transformers are required by either method.

Transmission in Closely Associated Circuits

When the same wires are used to provide both side circuit and phantom circuit transmission, it is a requirement of apparatus (such as transformers and filters) inserted in side circuits that they shall not impair transmission in the phantom circuit, and vice-versa. This means that apparatus in one circuit must not insert impedance in another circuit and requires close coupling between those impedance elements of networks which are located in series with the line wires.

Stability of Characteristics with Current Variations

If the inductances, resistances, or capacities of a network are subject to variations in value with varying current strength,—as for example, is the case with the inductance and resistance of coils using unstable core materials,—two detrimental results are possible. First the frequency characteristics of the network will be distorted as the current varies from its mean value. Second, a kind of modulation will occur, resulting in the generation of new frequencies whose presence will interfere with interpretation of signal waves traversing the network. Stability of characteristics is obviously to be secured by the use of materials whose permeability, resistance, and dielectric constant do not vary with current strength.

Low External Coupling

It is desirable that electrostatic and electromagnetic coupling between a network and parts of its own or other circuits be kept low; that is, that the network be self-contained electrically and receive and supply energy only through its normal input and output terminals. When coupling exists to some other circuit, (1) energy introduced from the latter circuit may interfere with signals or (2) energy derived from the network may cause interference in the circuit to which it is coupled. When coupling exists to other parts of the circuit in which the network is located, (1) impedance balances may be upset, (2) large attenuations, as of a filter, may be nullified by bypass circuits, and (3) circulating currents of considerable strength may be set up when vacuum tubes are involved in the circuit. Electrostatic and electromagnetic shielding permits control of external coupling.

Low Reflection Coefficient

Where networks connect directly or through other transmitting networks to a line, it is desirable that the impedance offered by the network-to-line currents be such that wave reflections are not set up in the line by impedance mismatches at its ends. Reflections result not only in undesirable transient waves in the circuit in which they originate, but cause interference into other circuits and complicate line transposition problems. Hence an impedance characteristic is usually prescribed for a network.

Parallel or Series Operation

It is a requirement, particularly of groups of wave filters selecting signals for a number of communication channels, that the impedance of each in the transmitting ranges of the others be such as not to interfere with the

operation of the latter. In the case of filters operated in parallel, this means a high shunting impedance; in the case of filters operated in series, a low series impedance. It is possible to meet this requirement since, in general, numerous configurations of filter elements which will meet given transmission requirements but allow wide latitude of choice of impedance characteristics, can be arranged.

A number of considerations should be noted with respect to the above requirements. First, in any given circuit conditions, the requirements can be expressed in numerical measure so that networks can be designed to meet them quantitatively, and measured accordingly when constructed. Secondly, the various requirements which might be imposed on a network by circuit conditions tend, for the most part, to be conflicting, since they restrict choices of design, and must be evaluated and balanced from an economic standpoint. Finally, the ability of a network to meet the above requirements is subject to physical limitations which will be discussed in Section IV.

IV. Engineering Limitations on Network Design and Construction

To work out theoretically a network of inductances, capacitances, and resistances which will offer certain desirable transmission characteristics over a frequency range, is a matter of following certain theoretical design methods. To build actual networks which will possess and retain these characteristics involves a large number of factors which come into play and which must be balanced against one another.

Accordingly, it is necessary to point out the principal directions in which limitations are to be encountered, for the value of network design methods is limited exactly by the degree to which networks may be physically constructed so as to give desired characteristics.

Between the indicated theoretical performance of a network and its actual performance there enter in generally four types of discrepancies. They are concerned with the following four questions: (1) How accurately does the indicated theoretical performance correspond to the exact theoretical network chosen? (2) How nearly is the actual form or configuration of the network what it is theoretically supposed to be? (3) How accurately is the network constructed? (4) How stable are the characteristics of the network during operation?

There are two sources of error which affect the theoretical exactness of the computed performance of a network; both have to do with the approximations which are necessary when mechanical aids are used in computation. One lies in computations of the network constants (L's, C's, and R's) from chosen significant frequencies, impedances, or other design bases, and the other, in determinations of the characteristics themselves either from the network constants or from the bases referred to. Ordinarily, when reasonable care is used, discrepancies of either kind are not large enough to be important except in the case of apparatus which needs to be made very accurately.

The form or configuration of a network introduces four important factors leading to discrepancies; *viz.*, (1) interactions between network elements, (2) distributed impedance effects in the elements themselves, (3) admittances from elements to ground, and (4) effects of the wiring system. These are important factors which generally must be given careful consideration.

For a given design, accuracy of network construction is dependent, primarily on (1) the accuracy of electrical measuring circuits used in conjunction therewith, (2) the fidelity of test conditions, and (3) the care and skill exercised in making adjustments. This assumes that the design is such mechanically as to permit close adjustments to be made.

Stability of network characteristics under operating conditions is largely dependent on the materials employed in construction. Suitable materials are usually limited in number either by economic considerations or by the limitations of engineering knowledge. The chief sources of instability of characteristics are: changes with current variations (either temporary or permanent), changes due to temperature and humidity fluctuations, and a group of changes called "aging" which have to do with releases of stresses and fatigue of materials.

ENGINEERS REVIEW PROGRESS

The summer convention of the American Institute of Electrical Engineers, held at Swampscott, Mass., last week, was notable for a group of technical committee reports that surveyed the several fields of engineering and for many papers that presented new developments in the art. It was made evident that the engineers are very busy these days and that the Institute is serving as a splendid rallying place for their social and technical activities.

* * * * *

The Institute is a needed agency in holding together the professional electrical engineers. It gives opportunity for the specialists to meet as a group to discuss their problems, and at the same time it serves as a unifying agency to weld together all electrical engineers into a professional entity. Moreover, it develops a sense of civic responsibilities and of the higher values in life so well outlined by President Schuchardt in his address. Any one who attended the Swampscott meeting came away with renewed loyalty and enthusiasm for the Institute and with the knowledge that the electrical engineers are continuing the work that is fundamental to the growth of the industry.—*Electrical World.*

Abridgment of

The Electrification of the Mexican Railway

BY J. B. COX[1]
Associate, A. I. E. E.

Synopsis.—The Mexican Railway Company, Ltd., locally known as Ferrocarril Mexicano, was the first railway built in Mexico, having been opened to traffic January 1, 1873. The main line runs between Mexico City and Vera Cruz and is 264 mi. in length. There are six branch lines which increase the route miles to a total of 482. The most difficult portion of the line consists of 19 mi. of 4.7 per cent grade between Encinar and Boca del Monte where the table-land is reached.

In 1921, when the road was returned to its owners, following five years of government operation, the property was found to be in an unsatisfactory condition, with operating expenses more than doubled, thereby increasing the operating ratio from 0.51 in 1914 to 0.79 in 1920. Higher wages and new working agreements were largely responsible and continued to become more difficult. The mountain division had about reached its maximum capacity with the existing equipment, making it necessary to consider improvements.

A study of the operating costs of this section was made in 1921 from which it was apparent that the electrification of that section would readily relieve the congestion and make it possible to more than double the capacity of the line, and at the same time accomplish a yearly saving of $523,000 in operating expense. The electrification was estimated to cost $2,420,000, thus indicating a return of 21 per cent on the gross investment including electric locomotives, in addition to the increased capacity and many other advantages.

Construction work was started in January 1923 and electrical operation between Orizaba and Esperanza was complete in January 1925. The total cost for the 29 mi. section was $2,427,480.00. Internal disturbances delayed the work several months and reduced the traffic greatly. In March and April 1928 the traffic becomes comparable with that of September and October 1921, for which period the actual traffic records and operating costs for steam operation had been used as a basis for comparison with the estimated cost of an equal traffic with electrical operation.

A comparison of actual operating costs of items affected by electrification for the two periods showed that 10 electric locomotives had hauled 36 per cent greater tonnage in 40 per cent less train hours than had 25 steam locomotives and at 50 per cent of the cost for items affected. When the figures were properly adjusted to compensate for increased tonnage and higher wages, the saving indicated was at the rate of $663,348 per year, a return of 26 per cent on the total cost of the electrification.

In the meantime the general results had been so satisfactory that the electrification was extended 35 mi. south to Paso del Macho, making a total of 64 mi. at a cost of $3,606,937.00.

THE electrification of the Mexican Railway (Ferrocacrril Mexicano) is of special interest as being the first undertaking of this nature carried out in old Mexico. The initial study of the problems involved was made in 1921, and in 1922 a contract was signed for the construction work and for the electrical equipment. In 1925 the work was completed and electrical operation started.

The operation has been so conspicuously successful that it would now seem to be of general interest to describe many of the details of construction and to give such operating data as are available.

The main line of the Mexican Railway extends from Mexico City to the Gulf Coast at Vera Cruz and is 264 mi. in length. There are six branch lines, making the total route miles 482.

From Mexico to Esperanza the line follows the general contour of the plateau, resulting in frequent reversal of gradients, but none exceeding 1.5 per cent. The elevation at the terminus in Mexico City is 7346 ft. The highest point on the line is near Acocotla, 95 mi. from Mexico, at an elevation of 8320 ft., a rise of about 1000 ft. From this point to Esperanza, a distance of 58 mi., the drop is 240 ft. with the surface undulating as before.

At Boca del Monte (The Mouth of the Mountain), 3.8 mi. west of Esperanza, the plateau ends suddenly, and the descent for the following 19.0 mi. to Encinar is very rapid.

At Santa Rosa the line enters the Valley of the Rio Blanca and the grade becomes normal on to Orizaba.

From Orizaba to Paso del Macho the drop is considerable though much less rapid than that just described. In the 35 mi. there is a descent of 2466 ft. There are some comparatively long sections of tangent track, and the curves, except in the loop on the Metlac Bridge, are not unusually numerous or seriously sharp.

The original charter for the road was granted in 1855 and it was opened for through traffic January 1, 1873, eighteen years later.

The history of its promotion, construction, and operation was in close synchronism with that of the country. The road had become prosperous during the comparatively settled conditions under the rule of Diaz, but the revolution of 1910 established a new government which, in November 1914, took the road from its owners and operated it until August 1916, when it was returned to the owners. It was again seized in April 1917 and held until June 1920, making more than five years of government operation.

When returned, the property was in very poor condition, much of the equipment being inoperative, and with no materials for repairs. Operating expenses had also been abnormally affected during the interval by substantial increase in wages, as well as by unusually expensive working agreements insisted on by newly formed labor organizations, all of which were becoming increasingly burdensome.

1. General Electric Co., Schenectady, N. Y.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Complete copies upon request.

The semi-annual reports of the Mexican Railway for the six months ending December 31, 1920, the first period of operation after the return of the property by the Government, compared with a similar period of 1913, the last six months of operation by the owners prior to Government operation for which the records were available, indicated that the operating costs had more than doubled during the interval, thereby increasing the operating ratio from 0.51 in 1914 to 0.79 in 1920.

In the fall of 1921 the business on the railway had grown so that it became very difficult to get the traffic over the mountain division from Orizaba to Esperanza, which had always been the proverbial bottle neck. On October 25 a total of 14 trains, two of which were passenger, (an aggregate of 4648 tons), was taken up the mountain, establishing a record for the division and indicating that the economic capacity of the single track line with existing type of motive power had been reached and that improvements of some kind were necessary.

In November 1921 a study of the mountain division was begun for the purpose of determining the results that might be expected from the electrification of this congested district. About two months were spent in looking over the line and equipment, studying the conditions and securing operating data and costs. An equal time was required to analyze these data, estimate the cost of electrification and the savings in operating expenses that would result, and to prepare a report which was submitted in April 1922.

The unsettled conditions that had existed in the country for the preceding ten years and the taking over of the railroad by the Government between 1914 and 1920 rendered the records for any of this entire period unsuitable for forming a basis for the usual method of estimating the traffic that might reasonably be expected over the line for the following years.

The management of the railway suggested that the months of September and October 1921 should be taken as a basis for the study since the traffic conditions and operating costs during that period were more representative of anticipated future conditions than any other period for which records were available.

The mountain district constituting the line between Orizaba and Esperanza, a distance of 29.5 mi., was then operated as a separate district, and accurate operating expenses and statistics for steam operation were readily available for comparison with corresponding estimated costs of electrical operation.

The line between Orizaba and Paso del Macho was also included in the original study, but since this was operated with the remainder of the line on into Vera Cruz and the result of electrification could not be so definitely determined until an exact schedule of operation had been decided upon, only an approximate estimate was made for this section.

Of the 29.5 mi. between Orizaba and Esperanza, the 19 mi. between Encinar and Boca del Monte which had been given careful consideration in the original survey again became the determining factor relative to motive power. The actual rise in the 19 mi. is approximately 3500 ft. equal to an uncompensated grade of 3.5 per cent. With the exception of the first 2.5 mi. of this heavy grade just out of Encinar there is practically no tangent track, but continuously reversing curves many of which are on a radius of 351 ft., equivalent to 16.5 deg.

In locating the line it was apparently intended to keep the uncompensated grade at a maximum not to exceed 4 per cent, and the maximum curve at 16.5 deg.

A check on the most difficult point on the line revealed that on short sections of the line 500 ft. in length the compensated grade was 5.24 per cent. The average grade for 1¼ mi. at this point was 4.7 per cent which was therefore considered the ruling grade for the division in preparing the specifications for electric locomotives.

The average weight of the passenger trains was about 235 tons but they varied between 165 and 350 tons.

The steam locomotives that were generally used for handling both freight and passenger trains on this division consisted of 32 four-cylinder Fairlie engines, of English build. These engines were designed especially for mountain service having pack-saddle type tanks for fuel oil and water over a double-ended boiler which was mounted on two three-axle swivel trucks, all the weight being on the drivers. The engines had the appearance of two three-axle switching locomotives coupled with cab ends together.

The firebox was in the middle of the engines and contained two oil burners, the cab being over this central portion and the engineer located on one side of the boiler with the fireman on the opposite side. The engines ran equally well in either direction, and having a comparatively short rigid wheel base with all weight on the drivers, at once deprived the electric locomotive of three of its usually boasted advantages.

The 32 engines were all of the same general type but of variable ages and weights ranging from 84 tons to 152 tons. Practically all freight trains and most of the passenger trains required two engines. In the case of the passenger trains, both Fairlie engines were placed at the head of the train with a box-car between; and with the freight trains, an engine was placed at each end. The average weight of the trains, up grade, was 317 metric tons or 350 U. S. tons. The down grade tons were considerably less as almost two-thirds of the traffic was northbound.

The operating data and actual costs of the steam operation for the months of September and October 1921 were taken as a basis for estimating the saving that might be expected to result from the electrification of the Orizaba–Esperanza district. Only the items of operating costs which would be most vitally affected were considered. The estimate as submitted in the report follows:

	Steam	Electric	Saving	Ratio steam to electric
Wages of enginemen	$108,892	$ 31,354	$76,538	3.44
Wages of trainmen	85,290	23,191	62,099	3.68
Fuel and power	221,790	150,000	71,790	1.48
Repairs to locomotives	355,248	51,111	304,157	6.95
Enginehouse expense	20,946	5,841	15,105	3.57
Lubricants	16,656	2,921	13,735	5.70
Substation oper. and maint.	..	11,750	..	..
Maint. distributing system	..	9,625	..	..
Total	$808,822	$285,793	$523,029	2.82

The estimated cost of the electrification as submitted was:

10–150-ton electric locomotive units	$1,420,000
1–6000-kw. substation	350,000
30–Route miles distributing system	430,000
Engineering and contingencies	220,000
Total gross capital investment	$2,420,000

The report accordingly indicated a probable saving of $523,029.00 per year by the expenditure of approximately $2,420,000; or a return of slightly more than 21 per cent on the gross investment which included electric locomotives.

A similar study of the line between Orizaba and Paso del Macho was made at the same time, but as the savings that seemed probable were sufficient for a return only about half that of the Orizaba–Esperanza district, the report recommended that only the latter be undertaken in the beginning.

After a very careful examination of the report by the Operating Department of the railway, it was approved and recommended to the Board of Directors.

In October 1922 a contract was made for the required equipment and materials including the general supervision of the installation. Actual work on the ground was begun in January 1923 and the work was completed and all trains being hauled electrically by January 1925.

Distribution System

The simple catenary system with a double 4/0 trolley over the main line and a single 4/0 trolley over passing tracks and yards, similar in general to that used on the Chicago, Milwaukee, St. Paul & Pacific Railway, was adopted.

Of a total of 1920 poles required for the supporting structure, 405 were concrete and 1515 were made from old 82-lb. rails which had been replaced and temporarily abandoned. The cost per pole was $45.52 for concrete and $34.00 for the rail.

Bracket construction was used generally. Two 500,000-cir. mil copper positive feeder cables and one 4/0 negative feeder cable were used over the greater distance of the line, and a single 250,000-cir. mil electrically-welded bond was installed at each rail joint. The cost of the distribution system inclusive of poles and fixtures for the 29.50 mi. was $462,011.00 or $15,661.00 per route mile including an 8-track yard one-half mile in length at Orizaba.

In 1926 the trolley line was extended 16 mi. eastward to Cordoba at a cost of $233,556 or $14,597 per route mile including an 8-track yard at Cordoba similar to that at Orizaba.

In May 1928 the distribution system was completed to Paso del Macho, 18.5 mi. south of Cordoba, with only a single 500,000-cir. mil copper positive feeder to Potrero and a 4/0 negative feeder throughout at a cost of $230,676.00, or $14,090.00 per mile. The total cost for the 64 route miles of distribution was $926,243.00, or an average of $14,472.00 per route mile.

Substation

One substation located at Maltrata, practically in the center of the distribution system,—10.2 mi. by feeder

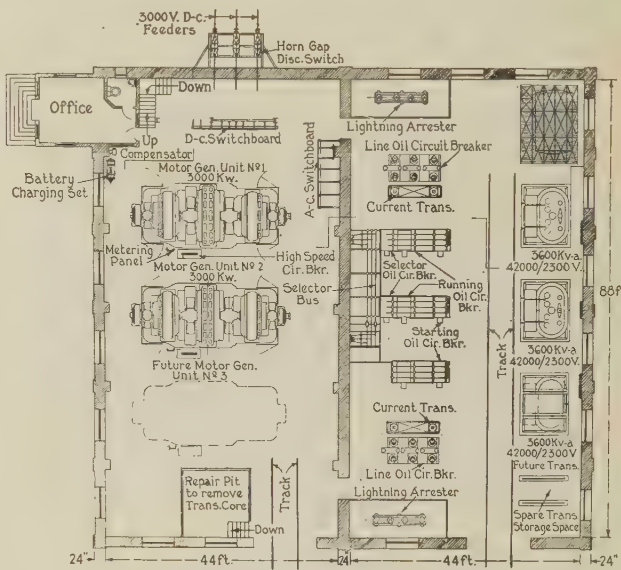


Fig. 8—Plan of Maltrata Substation Showing Location of Apparatus

from each end, and the Bota loop which is 7.5 mi. around, located in between—was sufficient for the service.

Fig. 8 shows a plan of this substation and Fig. 9 the interior of the generator room.

Power is purchased from the Puebla Tramway Light & Power Co. at 42,000 volts, three-phase, 60 cycles. The equipment of the substation consists of two three-unit, 3000-volt motor-generator sets, with transformers and switching gear, all of which are standard apparatus of the same general design as used on the Chicago, Milwaukee, St. Paul & Pacific, Spanish Northern and Paulista Railroads.

Building room and completed foundations are provided for a third similar unit when desired.

The extension to Paso del Macho required a second substation located at Potrero, 39 mi. from Maltrata. This is practically a duplicate of the Maltrata station except that the units are of 1500-kw. capacity, the grades being much less on this end of the electrified

section. The total cost of the Maltrata substation inclusive of buildings was $452,725 or $75.50 per kw. The cost of the Potrero station was $234,194, equal to $78.00 per kw. or an average for the two of $10,733.00 per route mile of electrification.

Locomotives

Ten 150-ton electric locomotive units, class B+B+B, equipped with six twin-geared motors, mounted on three articulated trucks, were supplied for the initial electrification. Each unit is capable of exerting a continuous tractive effort of 50,000 lb. at 18 mi. per hour with 2700 volts at the locomotive, and has three speed combinations which provide continuous running points for 6, 12, or 18, m. p. h. at full tractive effort; and two shunting points provide correspondingly higher speeds on each of these combinations with lighter loads up to 40 m. p. h. These locomotives are provided with regenerative braking features.

Two additional duplicate locomotives were supplied

Fig. 9—Interior of Maltrata Substation Showing two 3000-Kw., 3000-Volt Motor-Generator Sets and High-Speed Circuit Breakers

this year for the extension to Paso del Macho, making a total of 12 units for the 64 mi. of electrification. All locomotives are suitable for both freight and passenger service.

Transmission Line

A 42,000-volt transmission line, consisting of six steel centered 1/0 aluminum cable supported on "A" frame steel poles with anchor towers about each five pole, was built to bring the power from the Tuxpango Power House to Maltrata, a distance of 17 mi. The cost of this line was $187,242 or about $11,000.00 per mile. A similar line of about equal length, except that only three conductors will be installed for the present, is under construction to Potrero.

Electrical Operation

The Orizaba-Esperanza district has been in full operation electrically since January 1925, thus making the records available for four years. The operation has been quite successful, as may be judged from the total complaint account which was about $3,000.00, and by the maintenance and operating costs given herewith.

The rebellion which occurred unexpectedly in December 1923 not only increased the cost of the construction by completely stopping the work for four months just when fully organized, but was also responsible for a general recession in business which reduced the traffic over the electrified line to about 65 per cent of that for the period used in the estimate.

Early in 1928 traffic increased to a point some in excess of that during September and October 1921, thus affording an opportunity to check the estimates which had been made in the report leading to the electrification. Operating records practically identical with those for September and October, during steam operation, were obtained for the months of March and April 1928 with complete electrical operation. The comparison for the two periods showed that after proper adjustments had been made for increased prices, for fuel and wages and the excess tonnage, the operating costs for March and April with, electrical operation, were at the rate of $404,652.00 per year as against $1,068,000.00 per year with steam operation, thus indicating a saving of $663,348.00 per year or 62 per cent in favor of electrical operation.

The adjusted costs of steam operation and the actual corresponding costs of electrical operation placed on a yearly rate for direct comparison and for checking the estimate were as follows:

			Saving	
	Steam	Electric	Indicated	Estimated
Enginemen	$185,946	$87,390	$98,556	$76,538
Trainmen	130,332	64,326	66,006	62,099
Fuel or power	300,834	186,840	113,994	71,790
Repairs to locomotives	408,354	35,814	372,540	304,137
Enginehouse exp	23,388	11,670	11,718	15,105
Lubricants	19,146	552	18,594	13,735
Substa. oper. maint	..	12,924	..	..
Trolley oper. maint	..	5,136	..	..
Total	$1,068,000	$404,652	$663,348	$523,029

The indicated saving of $663,348.00 per year in favor of electrical operation is 27 per cent greater than the estimated saving of $523,029.00, but this is largely accounted for by the 36 per cent increased tonnage actually handled above that on which the estimate was based.

The savings indicated for the items listed represent 26 per cent earnings on the gross cost of the electrification of the 29.5 route miles of the district electrified, which alone should be considered a very satisfactory investment; but with the addition of the many other advantages resulting,—such as increased capacity of the line, reduction in running time, wear on wheels and brake shoes,—with consequent reduction of accidents from broken wheels due to overheating while braking, all of which, if fully valued would add many hundreds of dollars to the credit of electrical operation; those items ordinarily being too difficult to accurately segregate into definite amounts.

The earning on investment as shown is on the gross investment including the cost of electric locomotives, whereas steam locomotives to do an equal service on this section of steep grade would have cost approximately as much as the electric locomotives. Therefore, the cost of electrification should be entitled to a credit amounting to the cost of the locomotives, which in this case would reduce the cost of the electrification about 46 per cent, and thus make the earnings on the net investment for the electrification about 47 per cent.

The gross cost of the 64 route miles now electrified, including transmission line now under construction and two duplicate locomotives recently delivered, was approximately \$3,607,000.00 or \$56,358.00 per route mile electrified. The original estimate was \$4,032,500.00, but experience from the two years' operation of the original district made it evident that the traffic could be handled safely with 20 per cent less electric locomotives than had been thought necessary at the time the estimate was made.

Speed Indicator and Frequency Meter

BY E. H. GREIBACH[1]
Non-Member

Synopsis.—*The design of a simple mechanical speed indicator, consisting of a rotating cup and a ball placed inside of the cup, is described and discussed. This speed indicator can be built to give precise indication through a range of ± 2 per cent of a given speed. The order of precision in reading is about 1/10 of 1 per cent. When driven positively by a synchronous motor, it can be used as an accurate frequency meter.*

* * * * *

THE fact that centrifugal forces are proportional to the speed of rotation has been utilized in the design of many mechanical speed indicators. These indicators consist either of rotating masses whose centrifugal forces are balanced by means of springs or weights, or they are rotating containers in which liquids are made to assume various shapes. In the first case, a delicate system is required to indicate the position of the masses, while in the second case, a complicated shape of the container is required in order to get a correct and easily observable indication of the speed of rotation.

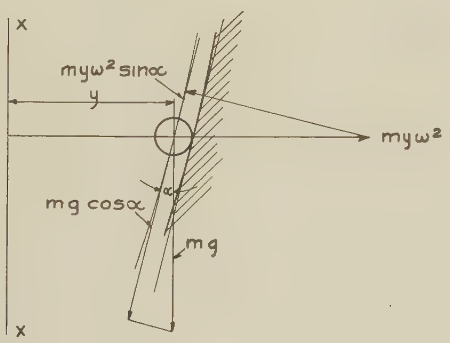


FIG. 1

Although based on the same law of proportionality between speed and centrifugal force, the apparatus described in this paper offers greater simplicity and ease of operation.

1. Research Department, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

A cup-shaped container, preferably transparent, rotates around a vertical axis. One or more balls of suitable material, such as steel, are placed inside the cup. These balls are subject to the influence of centrifugal forces as the cup rotates. (Fig. 1)

The centrifugal force acting on each ball has a component in a direction tangential to the generatrix of the inside surface of the cup. (Fig. 2) This component causes the ball to climb along the inside wall until it is counterbalanced by the component of weight acting in the opposite direction; or, in other words, the ball is in equilibrium on a point of the generatrix when the centrifugal force and gravity give a resultant which is perpendicular to the tangent. It is evident that the slope of the tangent is a function of the radius and the

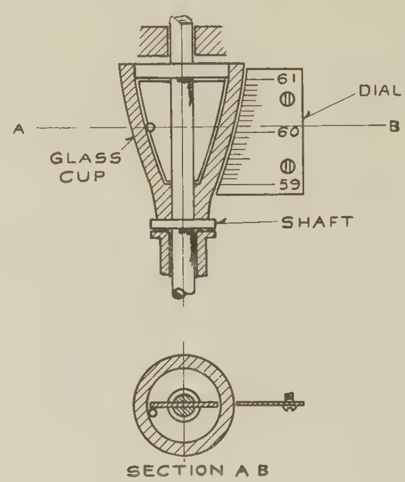


FIG. 2

angular velocity of the cup. Therefore, when a cup is made whose slope and radius vary in a proper manner, each point on the generatrix corresponds to a definite velocity for which the ball is at rest. By providing a stationary scale, properly graduated, the speed corresponding to each position of the ball can be read.

The inside surface of the cup can easily be calculated to give any required scale distribution. For most of the applications a uniform scale is desirable. The calculation carried out for a speed indicator having a uniform scale distribution shows that it is very easy to build cups for a narrow scale range; *i. e.*, cups which would indicate the speeds varying through a range of $\pm$ 2 per cent (or less) of a given speed. In the design of the cups, due consideration must be given to the rotatory velocity of the cup. It can be shown that the curvature of the generatrix of the cup surface varies inversely as n_0. Since a greater curvature is desirable in the design of the glass cup, it is advisable to reduce the cup velocity by means of gears when designing indicators for high velocities. The indications of the cup are independent of the specific mass of the material from which the balls are made; however, the diameter of the balls has a certain influence, an increase in the diameter of the ball will shift the scale into a slightly higher range. This influence of the diameter of the balls can be used while calibrating cups in order to correct for some deviation from the exact dimensions.

The cup must be set in vertical position to insure maximum accuracy. It should be pointed out, however, that precision in setting the cup, although desirable, is not essential for ordinary commercial purposes. If the cup is steep, this is true because for small angles of deviation from the vertical, the variation of the component of gravity parallel to the generatrix is negligible.

A desirable feature of the apparatus is its property of indicating only the average when the speed undergoes rapid fluctuations. This characteristic is easily explained by remembering that the ball, however small, possesses a certain amount of inertia and that the effect of friction is negligible against the effect of inertia. Furthermore, it was found by experiment that on account of the friction being very small, the indicator acts sluggishly; *i. e.*, the ball does not readily follow variations in the speed of the cup. Therefore it is necessary to provide a means of accelerating the ball. A convenient means is to use a transparent vertical plate inside of the cup, fastened to the shaft and extending, radially, close to the inner surface of the cup, as shown in Fig. 1.[2]

The indicator does not contain any parts that are subject to rapid wear or deterioration. It will maintain its calibration therefore, over an indefinite period of time.

The logical application for this instrument is for accurate indication of small variations in speed. By properly designing the cup, very positive indications of plus or minus 2 per cent of a given speed can easily be obtained. Of course the apparatus can be made to give indications of speeds varying over a much wider range if desired.

When driven positively by a small synchronous motor, this instrument can be used as a precise frequency meter, having a full scale range corresponding to two cycles or less when based on 60 cycles. As the cups can be made quite long, these frequency meters can be used to indicate frequency variations as low as one-tenth of one cycle.

2. The writer is indebted to C. R. Hanna for the suggestion of this construction of the accelerating plate.

ELECTRIC POWER IN THE SOUTH

That the electrical development of the southern states has been the most important factor in the economic renaissance of this section is generally recognized; but the fact that in recent years the South has been forging ahead electrically at a far more rapid rate than has the country as a whole may not be generally known.

The actual figures are rather amazing. They show that during the five-year period from 1922 through 1927 the increase in generator capacity in the 15 southern states was 122 per cent as compared with 80 per cent for the entire country; while the increase in kw-hr. output during the same period was 134 per cent in the South as compared with 85 per cent for the country as a whole.

During 1928 the increase in output for the entire country was nearly 10 per cent; while in the southern states alone, the increase was more than 15 per cent. The figures of the U. S. Geological Survey for the first two months of 1929, as compared with the same period of 1928, show that this ratio is still being maintained.

This rapid rate of increase brought the South's proportion of the total output of the entire country from approximately 16½ per cent in 1922 to more than 20 per cent last year. Production in the South last year was nearly eighteen billion kw-hr. as compared with less than eight billion in 1922.

There has been an amazing increase in efficiency of fuel plants in recent years. In 1919 coal consumption averaged 3.2 lb. per kw-hr., while in 1928 this had been reduced to 1.76 lb., or a reduction of nearly 50 per cent. But despite this increased efficiency of fuel plants, which has been widely proclaimed, the output by water power has increased more rapidly than the output by fuel power during the last four years. Last year nearly 40 per cent of the total output of the country was generated by water power, while in the southern states the proportion was nearly 50 per cent.—*Electrical South.*

TRANSATLANTIC TELEPHONE CABLE

Last year the American Telephone and Telegraph Company announced that the Bell Telephone Laboratories had perfected a deep sea telephone cable suitable for transatlantic operation. Work is now going forward actively on the development of a cable system of this type for connection between London and New York City and it is possible that this circuit will go in service as early as 1932. While the new cable will yield only a single telephone circuit, this will be one of maximum reliability, free from the variations characteristic of radio circuits. It is not the idea that the cable will replace radio circuits but it will add considerably to the reliability of New York-London service as well as adding to the total message capacity.

The route of the cable is not settled in detail, but it is probable that the main transatlantic link will extend directly from Newfoundland to Ireland, a cable length of approximately 1800 nautical miles. From Newfoundland it is expected that the circuit will be carried through several sections of submarine cable to Nova Scotia; thence by land circuits through Nova Scotia, New Brunswick, and the New England states to New York City, where it will terminate. From Ireland the circuit will probably be carried through submarine cable to Scotland and thence by land cable to London, which will be the other terminal.

The new cable will be of the continuously loaded type. For the loading material, it is planned to use one of a new series of alloys which are designated as "perminvars." These are composed of nickel, cobalt, and iron, to which may be added small amounts of non-magnetic metals such as molybdenum. They are characterized by high resistivity and by having a constant permeability over a wide range of magnetizing force.

The conductor will be insulated with a new material "paragutta." Submarine cables in the past have been insulated with gutta-percha or closely related materials, and in a few cases with rubber compounds. Paragutta makes use of similar raw materials, but so combined and treated as to give superior electrical properties with mechanical properties similar to gutta-percha.

A remarkable feature of the cable is the high attenuation which it is proposed to use. It is possible that successful operation can be obtained with an attenuation of approximately 150 db. for the high frequencies of the voice range. This is a much greater attenuation than that at which telegraph cables are operated. Such a high attenuation depends on two features of the cable; the characteristics of perminvar are such that a relatively high sending level can be used, and by means of special construction, the cable will be shielded against interference so that a very low receiving level can be employed.

To make two-way operation possible, voice-operated switching mechanisms will be required at the two terminals. These devices will permit the circuit to be operated only in one direction at a given time, this direction of transmission, however, being automatically controlled by the speech waves of the two talkers so that conversations may be carried on in a perfectly natural manner.

IRON AND STEEL PRODUCTION

Annual Report of Committee on Applications to Iron and Steel Production*

To the Board of Directors:

Because of the magnitude of the projects and the rapid development that is taking place in certain phases of the iron and steel industry, especially in regard to application of electric power an annual report of application of electric power, to the iron and steel industry must necessarily be a continued story from year to year. These developments are keeping pace with the investigation of the metallurgist, which investigations have resulted in new processes for shaping steel.

While during the past year, there have been no new steel plants built, many plants have added to their equipment. During the year of 1928, the steel industry purchased in main drive motors a total exceeding 200,000 hp., the units ranging from 300 to 7000 hp.

It is interesting to note that of this total, approximately 80 per cent are d-c. machines. This is largely a result of the installation of several new continuous mills with individual motor drive for each stand of rolls.

Synchronous motors for driving constant speed mills are increasing in number every year, and during the past year, synchronous motors have been supplied ranging in size from 400 to 5000 hp.

A mill drive of unusual interest which is now being installed is that for the 36-in. reversing Universal slabbing mill at the Steubenville, Ohio plant of the Wheeling Steel Corporation. This is the first instance in this country in which separate reversing motors are used for driving the horizontal and vertical rolls of the mill. The motor which will drive the horizontal rolls is a single-armature d-c. machine rated 7000 hp. continuous, 50/100 rev. per min., 750 volts.

The number of continuous mills having stands individually driven by adjustable speed motors still grows. The largest drive for a mill of this type which has been purchased during the year is that for the 60-in. wide strip mill at the Wheeling Steel Corporation's Steubenville plant. The total continuous rating

*COMMITTEE ON APPLICATION TO IRON AND STEEL PRODUCTION:
M. M. Fowler, Chairman,

A. C. Bunker,	A. M. MacCutcheon,	G. E. Stoltz,
F. B. Crosby,	O. Needham,	Wilfred Sykes,
A. C. Cummins,	A. G. Pierce,	T. S. Towle,
Samuel L. Henderson,	F. O. Schnure,	J. D. Wright.

Presented at the Summer Convention of the A. I. E. E., Swampscott, Mass., June 24-28, 1929. Printed complete herein.

29-104

of the motors on this mill is over 20,000 hp., and d-c. power will be furnished by three 4000-kw., motor-generator sets.

During 1928 the American Rolling Mill Company placed in service a new wide strip mill. This mill is laid out to produce strip material up to about 60 in. wide and is one of the largest strip mills yet installed. The total capacity of the 11 driving motors is 21,800 hp.

The manufacturers of wide strips continue to enlarge their manufacturing capacity and apparently the end of their research and development is not in sight. The success of wide strip rolling is in considerable measure due to the accuracy that can be secured through modern electric drives and control equipment using individual motor drive of stands.

Time limit control of acceleration has now been in use on mill auxiliary drive for three or four years and has proved extremely successful.

A mill type motor which completely meets the recent standardization rules of the Association of Iron and Steel Electrical Engineers in all respects as to rating, speed, and dimensions is now in successful operation in a large number of steel mills, one installation of almost 200 motors having been in use for a year and a half with no troubles.

As regards the construction and design of main roll motors, such machinery is now largely being fabricated from rolled steel products by means of arc welding. The magnet frames of practically all of the large d-c. machines are now constructed from rolled steel slabs with feet and lugs welded to them. The stator frames of synchronous and induction motors are fabricated from steel plates and bars welded together, and the rotors of some of the synchronous motors are also being fabricated from plates and slabs.

The use of these fabricated frames has reduced cost and reduced manufacturing time for large electric motors. It also improves commutation and other characteristics, and it has become a definite feature in the new era of steel mill electrification.

The statistics for 1928 show that there was a total of 188 cranes purchased in the iron and steel industry, all having electric drives.

In the field of yard transportation, the Diesel electric locomotive is proving extremely successful in reducing operating and maintenance cost.

During the current year, the Ward Leonard type of control has been successfully applied to blast furnace skip hoists at the Bethlehem Steel Company's Plant at Sparrows Point, and also at the Tennessee Coal and Iron Company in Alabama. Engineers may not generally appreciate the limitations of the hoist equipment of blast furnaces, particularly on those furnaces that have been greatly increased in size in the last few years and are equipped with hoists of the single bucket type. The Ward Leonard control installed at Sparrows Point has quite materially helped furnace filling conditions and made it possible to secure increased outputs on their furnaces.

The electrically operated mud gun is one of the most outstanding developments witnessed by the blast furnace industry in many years. Before describing the new gun and its operation, a brief consideration of the work previously involved in stopping an iron notch will perhaps aid the reader unfamiliar with blast furnace operation to grasp the significance of the new development.

Tapping holes in the early days of ironmaking were closed by ramming in balls of fire clay with what was known in blast furnace parlance as a stopping hook. The operation was performed by hand and required keeping the furnace off blast for a short period of time. As the size of the stacks was increased, higher blast pressures were used and higher production obtained. This increase in the quantity of molten metal in the hearth and the blast tested the skill of the furnace keeper in stopping back the notch so that the iron would not trickle through after the blast was applied.

The mud gun, which is operated by three mill type motors, enables the operator to stop back the notch without taking the furnace off the blast.

Public utilities are showing increased interest in the possibility of assuming steel mill, loads and have entered a few plants supplying a part of their power requirements. Because of the economical use of what have heretofore been waste gases around a steel mill, competition between the public utility and the steel mill in the generation of power is of course very keen. Apparently the possibility of a public utility entering a steel mill depends not upon its ability to take over existing load under competitive conditions, but the possibility of assuming new loads brought about by increased manufacturing capacity of the steel plant. This phase of the public utility power outlet is comparatively new, but is assuming greater importance each year.

During the current year, the first steel mill interconnected transmission system was placed in service by the Carnegie Steel Company and the National Tube Company in the Pittsburgh District. This transmission system consists of a long span, double-circuit tower line, similar in design to recent public utility practise. It is operated at the present time at 44,000 volts. Five steel mill and coke plant power plants, having generating equipment aggregating 150,000 kv-a., are interconnected. The purpose of this interconnection is to transmit in the form of electric power, excess by-product fuel available at any plant to other plants where a shortage of such fuel may exist. It is an essential feature in the complete utilization of excess blast furnace gas, coke breeze, etc.

INSTITUTE AND RELATED ACTIVITIES

A Most Enjoyable Summer Convention

HELD AT SWAMPSCOTT

One of the most thoroughly enjoyed meetings of the Institute was held June 24-28, when over 1000 members and guests attended the Summer Convention at the New Ocean House, Swampscott, Mass. A fine selection of technical papers and reports was presented, a number of business conferences and meetings was held, many inspection trips were taken, and a most complete entertainment program was offered.

Twenty-four papers and nineteen technical committee reports were presented in seven technical sessions. A summary of these sessions and their discussions is published in subsequent paragraphs of this report.

Conferences were held on June 24 under the auspices of the Sections Committee and the Committee on Student Branches. These were attended by Institute officers, Section Delegates, District representatives and other members. A report of these conferences is published in subsequent paragraphs.

The 1929 Annual Business Meeting of the Institute was held on the morning of June 25. After a short address of welcome by Hon. F. W. Cook, Secretary of State of the Commonwealth of Massachusetts, the official business of the meeting was transacted as reported elsewhere in this JOURNAL. The meeting concluded with an address by President R. F. Schuchardt, entitled "The Engineer, Practical Idealist." In this address, President Schuchardt touched on the opportunities and the responsibilities of the engineer to assume his appropriate place in our present changing civilization. His address is published on page 611 of this JOURNAL.

Another notable event was the presentation of the Lamme Medal on the evening of June 26. This medal was presented to A. B. Field to whom it was awarded as announced in the February JOURNAL, page 154 "for the mathematical and experimental investigation of eddy-current losses in large slot-wound conductors in electrical machinery." The medal was presented by C. F. Scott, Chairman of the Lamme Medal Committee. In addition to a response by the medalist there were short addresses by President R. F. Schuchardt, B. A. Behrend, and N. W. Storer. A more complete account of the presentation ceremonies is published elsewhere in this JOURNAL.

Following this, the John Scott Medal was also presented to Mr. Field. The presentation was made by National Secretary F. L. Hutchinson, acting on behalf of the Board of City Trusts of Philadelphia. The award was made for the same achievement for which the Lamme Medal was awarded to Mr. Field.

Dr. Elihu Thomson, Director of the Thomson Research Laboratory of the General Electric Co., was now introduced and he spoke very briefly about the fundamental electromagnetic relations discovered by Michael Faraday in 1831 the application of which during the last century has resulted in the development of modern electrical machines.

These medal presentations and addresses preceded a banquet; and an added feature which immediately followed the banquet was a brief talk by C. L. Edgar, President of the Edison Electric Illuminating Company of Boston. Mr. Edgar spoke on some of the pioneer steps in power system design which have been made by his company. W. F. Dawson, Chairman of the 1929 Summer Convention Committee, acted as toastmaster during the evening.

A most delightful popular lecture was given on the evening of June 25, by Dr. Harlowe Shapley, Professor of Astronomy at Harvard University and Director of the Harvard observatory. In a most interesting manner he told of some of the recent work in astronomy.

During the Convention, a very large number of inspection trips were taken to power plants, substations, telephone plants, factories, colleges, and points of historical and of scenic interest. Also, immediately after the Convention closed on June 28, a number of those present started on a three-day tour through the White Mountains.

Entertainment of the most enjoyable nature was offered throughout the meeting. Sports, dancing, and cards were enjoyed every day or evening. Golf, tennis, fishing, swimming, and trap shooting were partaken of by many. A particularly enjoyable event was an all-day outing on June 27 when a group of about 160 people traveled to Rye Beach, New Hampshire, where numerous field contests were held. A piano recital by Professor V. Karapetoff, with songs by Mrs. Underwood, contralto, was given on the evening of June 27.

Golf and tennis tournaments were played for the respective Mershon Cups. The winner of the golf tournament was W. S. Lee; G. S. Gibbs was the runner-up. In the tennis singles tournament, A. J. Gowan won first place while G. A. Sawin, Jr., won second. Prizes were given for various other competitions including several held at Rye Beach.

A meeting of the Board of Directors and several committee meetings were held during the Convention.

Much praise is due the local Summer Convention Committee for the excellence of arrangements and the high quality of the entertainment provided. This committee consisted of the following members who were officers of the committee or chairmen of other committees as indicated or general members: W. F. Dawson, *Chairman*; E. W. Davis, *Vice-Chairman*; H. B. Dwight, *Vice-Chairman*; C. S. Skoglund, *Vice-Chairman*; W. H. Colburn, *Secretary*; V. R. Holmgren, *Asst. Secretary*; F. L. Ball, *Treasurer*; H. P. Charlesworth, *Meetings and Papers*; W. B. Kouwenhoven, *Sections*; C. L. Edgar, *Finance*; C. A. Corney, *Trips*; F. S. Jones, *Transportation*; I. F. Kinnard, *Publicity*; W. E. Porter, *Hotel and Registration*; A. H. Sweetnam, *Sports*; Mrs. W. H. Timbie, *Ladies' Committee*; J. P. Alexander, G. J. Crowdes, W. S. Edsall, S. J. Eynon, J. W. Kidder, R. G. Porter, W. H. Pratt, Ernest Shorrock, D. F. Smalley, H. B. Wood.

CONFERENCE OF OFFICERS AND DELEGATES

In accordance with the practise followed since 1922, the first day of the Convention, Monday, June 24, was devoted to a Conference of Officers and Delegates held under the auspices of the Sections Committee and Committee on Student Branches. 49 of the 56 Sections were represented by Delegates. 5 District Secretaries and 8 representatives of District Committees on Student Activities were present. In addition to these official Delegates, a considerable number of Institute and Section officers, Branch Counselors, and other members were present.

The first session of the Conference was convened at 10:05 A. M., with Dr. W. B. Kouwenhoven, Chairman, Sections Committee, presiding. During the early part of the afternoon Sessions A and B were held in parallel, Dr. Kouwenhoven presiding over Session A, dealing with Institute and Section problems, and Vice-President J. L. Beaver, Chairman, Committee on Student Branches, presiding over Session B, dealing with Student Activities. During the latter part of the afternoon the two groups met together again to discuss matters of common interest.

The topics included in the program, which had been prepared

in advance by a special committee and mailed to the Delegates, are given below.

Announcements by Dr. W. B. Kouwenhoven, Chairman, Sections Committee.

Remarks by President Schuchardt.

Remarks by Presidential Nominee Smith.

Remarks by National Secretary Hutchinson.

The Institute Membership

(a) The Responsibility of the Sections to the Question of Institute Membership.

(b) The Policy Underlying the Securing of New Members.

(c) How May the Proportion of Membership in Higher Grades be Increased?

The Institute Publications

(a) What Changes Should be Made in the Present Institute Publications? (See A. I. E. E. Journal, January 1929, page 2).

(b) Can Papers be Published More in Advance of Presentation?

The Institute Section

(a) How Can the Institute Section Help the Members in Expressing Their Obligations to the Public?

(b) How May Cooperation Between the Section and Branches in the Same Locality be Increased?

(c) How May Contact be Made between the Section and Student Members Coming into the Section Territory?

Afternoon Sessions

Session A—Dr. W. B. Kouwenhoven, Chairman.

(a) "Regional" or "District" Meetings?

(b) How Can Attendance at Section Mee ings be Increased?

(c) The Establishment of Additional Engineering Societies.

(d) Questions and Answers Relative to Institute Affairs.

Session B—Professor J. L. Beaver, Chairman.

(a) The Transfer of Student to Associate.

(b) Compulsory Attendance at Student Branch Meetings as part of Curriculum. How Much Time and Participation in Branch Programs can be expected of Students, and should the Faculty be asked to give Credit for this Work?

(c) Status of Local Members in the Branch.

General Session—Dr. Kouwenhoven presiding.

The Post College Education of Engineers—Professor E. Bennett (See A. I. E. E. Journal, April 1929, page 310, and Foreword by President Schuchardt).

Discussion.

Copies of the Annual Report on Section and Branch Activities for the fiscal year ending April 30, 1929, were distributed at the Conference. Institute members may secure copies by applying to headquarters.

The following recommendations were adopted:

1. That provisions be made encouraging enrolled Students to become Associates upon graduation and remitting dues in part, according to some suitable plan to be developed by a special committee.

2. That the conventions held in individual Districts and heretofore designated as "Regional Meetings" be called "District Meetings" in the future.

3. That consideration be given to the desirability of having the appropriation year for Sections begin August 1 instead of October 1.

At a meeting of the Board of Directors held at the Convention on June 25, these recommendations were considered favorably, and were referred to the proper committees and officers for study as to details.

In addition to the session on Monday afternoon, the Counselor Delegates and others especially interested in Student Activities held a session Monday evening for further discussion of the subjects given in the program for Session B and related matters. They recommended that headquarters send to each Counselor about February 1 a list of names of the enrolled Students of the Institute in his institution, indicating those who had and those who had not paid their enrolment fees for the current year.

An abstract of the proceedings of the entire Conference will be printed in pamphlet form and mailed to all Delegates present and to Institute, Section, and Branch officers. Any Institute member who is interested may obtain a copy of the pamphlet without charge upon application to Institute headquarters.

REPORT OF TECHNICAL DISCUSSION

The following is a condensed report of discussion at the technical sessions, together with the titles of the papers at each session. Complete discussion will be published with the respective papers in the Transactions.

A—Distribution and Power Generation

Presiding Officers:

H. A. Kidder, Vice-President, A. I. E. E.

F. A. Allner, Chairman of Committee on Power Generation

H. R. Woodrow, Chairman of Committee on Power Transmission and Distribution

Rehabilitation and Rebuilding of Steam Power Plants, C. F. Hirshfeld, Detroit Edison Co.

Symposium on *Synchronized at the Load*

I. *A Fundamental Plan of Power Supply*, A. H. Kehoe, United Electric Light & Power Co.

II. *Calculations of System Performance*, S. B. Griscom, Westinghouse Electric & Mfg. Co.

III. *System Tests and Operating Connections*, H. R. Searing and G. R. Milne, United Electric Light & Power Co.

Automatic Transformer Substations of Edison Electric Illuminating Co. of Boston, W. W. Edson, Edison Elec. Ill. Co. of Boston

Application of Induction Regulators to Distribution Networks, E. R. Wolfert and T. J. Brosnan, Westinghouse Electric & Mfg. Co.

In discussing Mr. Hirshfeld's paper, E. S. Fields told how power-station changes on the system of the Columbia Gas & Electric Corp. had increased the capacity by 105,000 kw. without necessitating any building additions. Four 25,000-kw. turbo generators were changed by minor rebuilding of the turbines and putting in new 36,000-kw. generators. Steam pressure was raised from 230 to 250 lb. and temperature from 600 to 700 deg. In another station 45,000-kw. tandem-compound turbines were rebuilt as 65,000-kw. cross-compound. Steam pressure was raised from 600 to 650 lb. and temperature from 725 to 740 deg. The boilers were changed to give greater output and electrical equipment was changed to take care of the increased turbine output. W. S. Lee brought out the advantage of placing generating stations at the proper points in relation to the load. He warned against the assumption that high steam pressure is a panacea for all troubles. W. J. Foster declared that the rehabilitation of old hydraulic generators is often more profitable than that of steam-turbine generators, a 50 per cent increase in output being sometimes feasible. L. W. W. Morrow pointed out that enormous increases in thermal economy of steam stations have been made in the last twenty years (from 32,000 B. t. u. in 1908 to 12,000 B. t. u. in 1928) and this has been accomplished without materially increasing the investment cost per kw. capacity which has remained at about $100 as an average.

As an addition to the symposium on *Synchronized at the Load* G. R. Milne presented some operating data on the system described. He said no major trouble had been experienced during four months of operation. Voltage dips at the load have been reduced 50 per cent. A phase-to-neutral fault on the reserve bus at Hell Gate Station caused little disturbance. The voltage at the load dropped only 8.7 per cent. E. E. Chilberg mentioned the advantages of using double-winding generators with this

scheme of connection. R. H. Tapscott stated that the New York Edison Company is installing a 160,000-kw. double-winding generator. In a written discussion E. C. Stone stated that the advantages of the synchronized-at-the-load scheme cannot well be applied to the system of the Duquesne Light Co. because there would be only two transmission lines per generating unit and the failure of one would cause a relatively great disturbance. Moreover a large proportion of the load is supplied at 22,000 and 11,000 volts, which would also be disadvantageous in the new scheme.

B—Transportation

Presiding Officers:

E. B. Merriam, Vice-President, A. I. E. E.

N. W. Storer, Past-Chairman of Committe on Transportation

Electrification of the Mexican Railway, J. B. Cox, General Electric Co.

Contact Wire Wear on Electric Railroads, I. T. Landhy, Illinois Central Railroad Co.

An Electrified Railroad Substation, J. V. B. Duer, Pennsylvania Railroad

D-C. Railroad Substations, A. M. Garrett, Commonwealth Edison Co.,

In discussing Mr. Cox's paper, D. C. Jackson emphasized the need of actual records instead of estimates on the costs of electrification and electric operation. Sidney Withington stated that he would like to see Mr. Cox's comparison include also the most modern steam locomotive. W. B. Potter pointed out that the electric locomotives require considerably less maintenance than steam locomotives. He stated that the locomotive is by far the most important part of an electrification project.

In connection with Mr. Landhy's paper, Sidney Withington emphasized the necessity for the development of a suitable means of lubricating a contact wire. He stated that in Europe lower pantographs pressures (7 or 8 lb.) are used with pantographs having a light auxiliary bow which carries the shoe. He said that certain results led him to believe that current density affects trolley wear. C. S. Anderson stated that cadmium bronze wire wears better than other contact wires and that it does not become brittle In answer to a question, Mr Landhy and several others agreed that a double contact shoe is better than a single shoe because one element of the double shoe is in contact with the wire almost all the time which eliminates destructive arcing.

In answer to a question on his paper Mr. Garrett said that rectifiers and rotary converters can be paralleled very satisfactorily.

C—Technical Committee Reports

Presiding Officer:

J. L. Beaver, Vice-President, A. I. E. E.

Research, F. W. Peek, Jr., Chairman

Electrophysics, V. Karapetoff, Chairman

Education, Edward Bennett, Chairman

Instruments and Measurements, Everett S. Lee, Chairman

Communication, H. W. Drake, Chairman

Power Generation, F. A. Allner, Chairman

Power Transmission and Distribution, H. R. Woodrow, Chairman

Protective Devices, E. A. Hester, Chairman

Automatic Stations, W. H. Millan, Chairman

In discussing the report of the Committee on Education F. C. Caldwell suggested that attention should be directed toward schools which give slightly lower courses than the engineering colleges, with less theoretical studies. Charles Ficklenburg advocated more thorough teaching of mechanical structures.

In connection with the report of the Committee on Instruments and Measurements F. A. Wolff, advocated the developmen of concrete standard units simultaneously with absolute units.

Commenting on the report of the Committee on Automatic Stations, Chester Lichtenberg drew attention to the need for standardizing voltage on supervisory control systems. H. P. Sleeper made a plea for the keeping of complete records of operating results in automatic stations.

D—Technical Committee Reports

Presiding Officer:

O. J. Ferguson, Vice-President, A. I. E. E.

Electrical Machinery, W. J. Foster, Chairman

General Power Applications, J. F. Gaskill, Chairman

Transportation, W. M. Vandersluis, Chairman

Applications to Iron and Steel Production, M. M. Fowler, Chairman

Applications to Mining Work, Carl Lee, Chairman

Applications to Marine Work, W. E. Thau, Chairman

Electrochemistry and Electrometallurgy, George W. Vinal, Chairman

Electric Welding, A. M. Candy, Chairman

Production and Application of Light, B. E. Shackelford, Chairman.

Commenting on the report of the Committee on Electrical Machinery W. J. Foster emphasized some of the advantages of hydrogen ventilation. C. J. Fechheimer explained the advantages of the double-entrance fan.

Edwin Fleischman, in connection with the report of the Committee on Electrochemistry and Electrometallurgy, called attention to the advantages of the nitriding process of hardening the surface of steel objects. Electric furnaces are employed in this process. J. C. Lincoln explained a method of nickel plating, called the degasification process, in which nickel is deposited to a thickness of 1/16 in. after which the plated piece may be rolled to ¼ its thickness.

In connection with the report of the Committee on Electric Welding, J. C. Lincoln said that his company uses electric welding in making many kinds of electrical machinery, and that the cost is considerably less than that of the older methods employing casting.

E—Miscellaneous

Presiding Officers:

B. D. Hull, Vice-President, A. I. E. E.

H. W. Drake, Chairman of Committee on Communication

J. F. Gaskill, Chairman of Committee on General Power Applications

Master Reference System for Telephone Transmission, W. H. Martin, American Tel. & Tel. Co., and C. H. G. Gray, Bell Telephone Laboratories, Inc.

Electrical Wave Analyzers for Power and Telephone Systems, R. G. McCurdy and P. W. Blye, American Tel. & Tel. Co.

A New Automatic Synchronizer, F. H. Gulliksen, Westinghouse Electric & Mfg. Co.

High-Frequency Portable Electric Tools, C. B. Coates, Chicago Pneumatic Tool Co.

Design of Electric Heating Elements, Edwin Fleischmann, The Niagara Falls Power Co.

J. J. Smith and J. O. Coleman stated that they had used the wave analyzers described in the McCurdy and Blye paper and had found them very useful and satisfactory.

In discussing Mr. Coates' paper, A. M. MacCutcheon emphasized the fact that 5 to 7 hp. is developed in 50 lb. of material in the high-speed tools and this weight includes all mechanical parts. He described a type of frequency converter which he said gives excellent voltage regulation. It consists he said of a rotating member into which alternating current is fed through slip rings. The output is taken from a commutator. The output frequency varies with the speed of rotation. F. L. Snyder pointed out that the induction frequency changer is usually less expensive than the motor-generator frequency changer. He suggested also that where distribution distances are great, the 180-cycle energy might be distributed at 440 volts and stepped down to 110 volts at the tool. B. B. Ramey stated that ventila-

tion of the tool is more easily accomplished with the 180-cycle tools than with 60-cycle universal motors. He suggested that power companies might in the future supply 180-cycle energy from their lines. Mr. Coates said that about 60 per cent of the present installations use the induction converter and 40 per cent use the motor generator.

F—Electrical Machinery

Presiding Officers:

W. T. Ryan, Vice-President, A. I. E. E.

W. J. Foster, Chairman of Committee on Electrical Machinery

Safe Loading of Oil-Immersed Transformers, E. T. Norris, Ferranti, Limited

Induction Motor Operation with Non-Sinusoidal Impressed Voltages, L. A. Doggett and E. R. Queer, Pennsylvania State College

Outdoor Hydrogen-Ventilated Synchronous Condensers, R. W. Wieseman, General Electric Co.

Short-Circuit Torque in Synchronous Machines Without Damper Windings, G. W. Penney, Westinghouse Elec. & Mfg. Co.

Analytical Determination of Magnetic Fields, B. L. Robertson, Pennsylvania State College, I. A. Terry, General Electric Co.

Commenting on the paper by Mr. Norris, F. F. Brand drew attention to the fact that large transformers with hot-spot indicators have been in service in America for a number of years. He claimed that the A. I. E. E. rules are not too conservative in limiting temperature as an operating temperature lower than 105 deg. is desirable to insure long life of insulation and oil. W. F. Dawson said it would be dangerous to apply the proposal of Mr. Norris to turbo alternators. W. M. Dann stated that many American operators are well satisfied with the margin of safety which the A. I. E. E. rules insure. He said, however, that the Institute is working on recommendations for operation of transformers by temperature. V. M. Montsinger claimed that some of Mr. Norris' calculations did not seem sufficiently accurate. He also objected to establishing 105 deg. cent. as a safe temperature for continuous operation. He thought that according to present knowledge 95 deg. by hot-spot indicator should be the limit. F. D. Newbury stated that sufficient records are not available to prove that the A. I. E. E. rules are too conservative and that therefore the present limitations should be kept to allow a margin of safety.

Commenting on the paper by Messrs. Doggett and Queer, R. G. McCurdy stated that usually the harmonics produced by receiving apparatus are greater than those put out by the generators.

Philip Sporn, in connection with Mr. Wieseman's paper, stated that generators offer the next opportunity for ventilation by hydrogen. This, he said, may facilitate the design of higher-voltage generators and of outdoor generators. C. J. Fechheimer explained that although the construction of a hydrogen-ventilated generator would be more difficult than a converter, the explosion danger would be very small and that previous use of a scavenging gas will minimize this difficulty. He said he believed the cost of a hydrogen-ventilated generator would be less than that of an air-cooled generator of the same rating. L. A. Doggett said it might be desirable to keep the air outside the machine in circulation so as to avoid explosions there. B. A. Behrend pointed out that another method of cooling stators of rotating machines is by means of oil. This is being tried in England, he said. He mentioned the advantages of using non-corrosive alloys for outdoor machines. F. D. Newbury stated that the danger of explosion is very small even with machines made without the precautions taken by Mr. Wieseman. A hydrogen-cooled generator he said will be perfectly safe indoors.

K. A. Reef explained how the solutions given in Messrs. Robertson's and Terry's paper might be applied to more general cases of slot design for d-c. machines.

G—Symposium on Shielding in Electrical Measurements

Presiding Officer:

E. S. Lee, Chairman of Committee on Instruments and Measurements

1. *Shielding and Guarding Electrical Measuring Apparatus*, H. L. Curtis, Bureau of Standards
2. *Some Problems in Dielectric Loss Measurements*, C. L. Dawes, P. L. Hoover and H. H. Reichard, Harvard University
3. *Shielding in High-Frequency Measurements*, J. G. Ferguson, Bell Telephone Laboratories
4. *Shielding of Cables in Dielectric Loss Measurements*, E. H. Salter, Elec. Testing Laboratories
5. *Precautions Against Stray Magnetic Fields in Measurements with Large Alternating Currents*, F. B. Silsbee, Bureau of Standards
6. *Magnetic Shielding in Electrical Measurements*, S. L. Gokhale, General Electric Co.

Several of the discussors complimented Dr. Curtis on his definitions of shielding and guarding. W. B. Kouwenhoven described an air condenser which he has developed which has very low loss. Humidity above 90 per cent he said will cause errors. I. M. Stein suggested that a standard condenser be built, probably by the Bureau of Standards, which can be transported from one laboratory to another.

L. E. Cirella said that he had been using a bridge like the one described by Messrs. Dawes, Hoover and Reichard and that most of the difficulties had been avoided. H. W. Lamson suggested that a tuned detector might prove useful in Professor Dawes' work. P. H. Humphries presented a mathematical derivation of the bridge equations and an analysis of the conditions for balance of the bridge described in Professor Dawes' paper. C. T. Weller asked if capacitance is as satisfactory as resistance for the bridge arms. T. F. Peterson gave some information on the high-voltage bridge which has been developed by H. J. Ryan at Stanford University. V. A. Thielman disagreed with the contention of the authors that shielding of a cable may increase power factor and loss.

P. S. Bower called attention to the difficulty of determining equivalent inductance and capacitance at high frequencies.

In connection with Mr. Salter's paper, E. W. Davis pointed out the deleterious effects of voids in cables. D. W. Roper mentioned tests which he is making on samples of several makes of single-conductor cable in which inductive effects in the lead sheath must be compensated for. Mr. Salter stated that for two years his results obtained on 10-ft. samples have checked very closely with factory measurements on full reels.

S. L. Gokhale, in referring to Doctor Silsbee's paper, told of a method he employs to compensate for a stray magnetic field that is not uniform. Doctor Silsbee agreed that the results were desirable but that the method might be complicated.

Hans Lippelt complimented Mr. Gokhale's treatment of magnetic shields and added further details on some points.

ANNUAL MEETING OF THE INSTITUTE

Swampscott, Mass., June 25, 1929

The Annual Meeting of the Institute was held at the New Ocean House, Swampscott, Massachusetts, on Tuesday morning, June 25, 1929, during the annual Summer Convention, President R. F. Schuchardt presiding.

The Annual Report of the Board of Directors was presented in abstract by National Secretary F. L. Hutchinson. Printed copies were distributed to members in attendance and are available to any member upon application to Institute Headquarters, New York. The report, which constitutes a resume of the activities of the Institute during the fiscal year ending April 30, 1929, showed a total membership on that date of 18,133. In addition to the three National conventions and three Regional meetings, 1400 meetings were held during the year by the local organizations of the Institute in the principal cities and educational institutions in the United States and Canada.

The report will be published in full in the quarterly TRANSACTIONS of the Institute.

The report of the Committee of Tellers on the election of officers of the Institute was presented as published in the July issue of the JOURNAL, and in accordance therewith, President Schuchardt declared the election of the following officers, whose terms will begin on August 1, 1929:

President: HAROLD B. SMITH, Professor of Electrical Engineering and Director of the Department, Worcester Polytechnic Institute, Worcester, Mass. (See biographical sketch in July issue of the JOURNAL, p. 564.)

Vice-Presidents: EDMUND C. STONE, Manager, System Development Department, Duquesne Light Co., Pittsburgh, Pa.

WALTER S. RODMAN, Professor in charge of the School of Electrical Engineering at the University of Virginia, Charlottesville, Va.

HERBERT S. EVANS, Dean, College of Engineering and Head of the Department of Electrical Engineering at the University of Colorado, Boulder, Colorado.

CLARENCE E. FLEAGER, Assistant Vice-President, Pacific Tel. & Tel. Co. San Francisco, Calif.

CHARLES E. SISSON, Transformer Engineer, Canadian General Electric Company, Ltd., Toronto, Ontario, Canada.

Directors: JOHN E. KEARNS, Electrical Engineer, General Electrical Co., Chicago, Ill.

WILLIAM S. LEE, Consulting Engineer, Charlotte, North Carolina.

CHARLES E. STEPHENS, North Eastern District Manager, Westinghouse Electric & Mfg. Company, New York.

National Treasurer: GEORGE A. HAMILTON, Elizabeth, N. J., (reelected).

These officers, together with the following hold-over officers, will constitute the Board of Directors for the next administrative year, beginning August 1: R. F. Schuchardt (retiring President), Chicago, Ill.; Bancroft Gherardi, New York, N. Y.; E. B. Merriam, Schenectady, N. Y.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; B. D. Hull, Dallas, Texas; G. E. Quinan, Seattle, Wash.; I. E. Moultrop, Boston, Mass.; H. C. Don Carlos, Toronto, Ont.; F. J. Chesterman, Pittsburgh, Pa.; F. C. Hanker, East Pittsburgh, Pa.; E. B. Meyer, Newark, N. J.; H. P. Liversidge, Philadelphia, Pa.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; A. E. Bettis, Kansas City, Mo.

President-elect Smith was called upon and responded with a brief address which was enthusiastically received.

The report of the Committee on Award of Institute Prizes, as published in the June issue of the JOURNAL, was read by the Chairman H. P. Charlesworth and prizes for papers presented during 1928 were presented by President Schuchardt.

The annual presidential address was then delivered by President Schuchardt, the subject being "The Engineer, Practical Idealist." This address is published in full on page 611 of this issue.

The Annual Meeting then adjourned and was immediately followed by technical sessions as reported elsewhere in this issue.

The Chicago Regional Meeting in December

A three-day regional meeting will be held in Chicago, December 2-4, 1929, under the auspices of the Great Lakes District of the Institute.

Four technical sessions are being planned, the general subjects of which will be power stations, transmission and distribution, communication, and general research and development. There will also be Student meetings. Of details, later issues of the JOURNAL will give more.

The Lamme Medal

THE 1929 NOMINATIONS FOR THE 1929 AWARD WILL BE RECEIVED UNTIL SEPTEMBER 1

The Lamme Medal was founded as a result of a bequest of the late Benjamin G. Lamme, Chief Engineer of the Westinghouse Electric & Mfg. Company, who died July 8, 1924, to provide for the award by the Institute of a gold medal (together with bronze replica thereof) annually to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery," and for the award of two such medals in some years if the accumulation from the funds warrants.

The first (1928) Lamme Medal has been awarded to Allan Bertram Field, Consulting Engineer, Metropolitan Vickers Electrical Company, Ltd., Manchester, England, "for the mathematical and experimental investigation of eddy current losses in large slot-wound conductors in electrical machinery," and was presented during the Summer Convention at Swampscott, Mass., June 24-28.

Special attention is called to the fact that names of members of the Institute, who are considered suitable candidates for the Lamme Medal to be awarded in the Fall of 1929, may be submitted by any member in accordance with Section 1 of Article VI of the By-laws of the Lamme Medal Committee, which is quoted below:

"The Committee shall cause to be published in one or more issues of the A. I. E. E. JOURNAL each year, preferably including the June issue, a statement regarding the 'Lamme Medal' and an invitation for any member to present to the National Secretary of the Institute by September 1 the name of a member as a candidate for the Medal, accompanied by a statement of his 'meritorious achievement' and the names of at least three engineers of standing who are familiar with the achievement."

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, which will enable the Committee to determine its significance as compared with those of other candidates. If the work of the nominee has been of a somewhat general character, in cooperation with others, specific information should be given regarding the contributions of the individual. Names of endorsers should be given as specified above.

Electrochemist to Discuss Aviation Materials

The American Electrochemical Society will hold its Fall Convention in Pittsburgh, Pa., September 19 to 21 inclusive to discuss, among other subjects, the chemical industry's contributions to aeronautics. Several hundred chemists, metallurgists, plant executives, and company officials of both the United States and Canada will be present to discuss recent developments in the electrochemical field.

The program will include visits to various industrial plants in the Pittsburgh district, and technical sessions with papers on pertinent subjects presented by various prominent men from all over the country. There will be a special symposium on "Contributions of Electrochemistry to Aeronautics," with emphasis given to the light weight aluminum and magnesium alloys used in aeroplane construction.

Social features of the meeting will include a smoker, a dinner and dance, with a special program for the ladies of the party. Headquarters will be at the William Penn Hotel, 5th Avenue and William Penn Way.

The Pacific Coast Convention

HAS NOTABLE PROGRAM ARRANGED FOR SEPTEMBER 3-6

Grounds of Hotel Miramar, Santa Monica, Calif., A. I. E. E. Convention Headquarters

A program of unusual interest is planned for the coming Pacific Coast Convention of the Institute which will be held September 3-6, with headquarters at the Hotel Miramar, Santa Monica, Calif. Some live technical subjects will be discussed, and trips, sports, and entertainment will be enjoyed. The ladies who attend will be treated to some delightful events arranged especially for them.

The technical papers will deal with such subjects as transmission, insulator flashover, wood pole insulation strength, series synchronous condensers, system stability, high-voltage fuses, transformers, insulating oils, arc flames, electrical conductivity, gas-filled tubes, sound pictures, dial telephony, load forecasting, wind-tunnel equipment, turbo generators and a-c. networks.

There will also be two Student sessions at which twelve Student technical papers will be presented.

The program of events is shown in the following outline.

TENTATIVE PROGRAM

Morning, September 3

Technical Session

Radio Interference from Line Insulators, E. Van Atta, Pacific Power & Light Co., and E. L. White, Puget Sound Power & Light Co

Spray and Fog Tests on 200-Kv. Insulators, R. J. C. Wood, Southern California Edison Co.

The 60-Cycle Flashover of Long Suspension Insulator Strings, R. H. Angus, Stanford University.

Impulse Insulation Characteristics of Wood Pole Lines, H. L. Melvin, Electric Bond & Share Co.

Afternoon, September 3

Student Technical Session

Experience with a Cathode-Ray Oscillograph in a College Laboratory, C. C. Lash, Graduate Student, California Institute of Technology.

Lichtenberg Figures, O. C. Mayer, University of Idaho.

Characteristics of Electrostatic Loud Speakers, F. J. Somers and George Mattos, University of Santa Clara.

Flashover Phenomena in High-Voltage Engineering, W. G. Hoover and Corbett McLean, Graduate Students, Stanford University.

Voltage Distribution on High-Tension Insulators, Floyd Gowans and Ned Chapman, University of Utah.

Voltage Amplification of the Screen-Grid Tube as an Intermediate-Frequency Amplifier, Frank Giovanini, Graduate Student, University of Washington.

Evening, September 3

Reception, followed by dancing.

Morning and Afternoon, September 4

Inspection Trips and Sports.

Evening, September 4

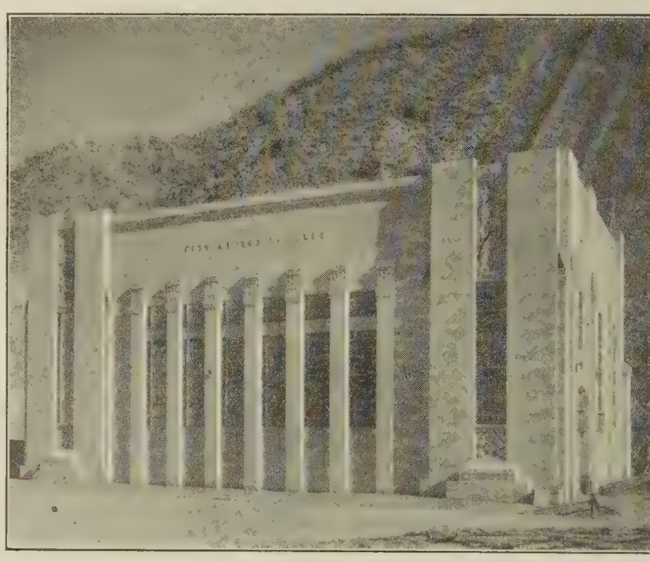
Lecture—"Recent Developments in the Theory of Electrical Conductivity," by W. V. Houston, California Institute of Technology.

Dancing will follow the lecture.

Morning, September 5

Student Technical Session

Influence of Rotor Impedance on the Starting Characteristics of Squirrel-Cage Induction Motors, A. V. Haeff, Graduate Student, California Institute of Technology.



San Francisquito Hydroelectric Plant No. 2 of the Department of Water and Power, City of Los Angeles

The Heating of Copper Conductors by Transient Electric Currents, S. O. Rice, Oregon State College.

Cyclic and Transient Illumination of Incandescent Lamps as Measured by the Photoelectric Cell, Z. J. Atlee and R. W. Mige, Oregon State College.

Study of the Losses in a 25,000-Kv-A., A. C. Generator, J. G. Pleasants and M. Tucker, University of Southern California.

The Operation of Synchronous Motors in Series, C. R. Koch, Graduate Student, Stanford University.

Power Losses by Radiation from Domestic Hot-Water Tanks, R. D. Wailes, University of Washington.

Afternoon, September 5

Technical Session

Development of Insulating Oils, C. E. Skinner, Westinghouse Electric & Mfg. Co.

Effect of Tank Color on Temperature of Transformers under Service Conditions, V. M. Montsinger and L. Wetherill, General Electric Co.

Population as an Index to Electrical Development, N. B. Hinson, Southern California Edison Co.

Flames from Electric Arcs, J. Slepian, Westinghouse Electric & Mfg. Co.

View of Main Switching Station (Lawrence Street) of Los Angeles Gas & Electric Corporation

Design Features that Make Large Turbine Generators Possible, W. J. Foster and M. A. Savage, General Electric Co.

Evening, September 5

Banquet, with special Entertainment.

Morning, September 6

Technical Session

Effects of Surges on Transformer Windings, J. K. Hodnette, Westinghouse Elec. & Mfg. Co.

An A-C. Low-Voltage Network without Network Protectors, L. R. Gamble and Earl Baughn, The Washington Water Power Co.

Low-Current High-Voltage Protective Equipment, Roy Wilkins, Pacific Electric Mfg. Corp.

Precision Speed Regulation for the Wind-Tunnel Motor at California Institute of Technology, W. A. Lewis, Jr., California Institute of Technology.

Afternoon, September 6

Technical Session

The Electrical Engineering of Sound-Picture Systems, T. E. Shea, Bell Telephone Laboratories and K. F. Morgan, Electrical Research Products Corp.

Dial Telephone System Serving Small Communities of Southern California, F. W. Wheelock, Southern California Telephone Co.

Parallel Operation of Transformers whose Ratios of Transformation are Unequal, Mable Macferran, Southern California Edison Co.

Progress in the Study of System Stability, I. H. Summers and J. B. McClure, General Electric Co.

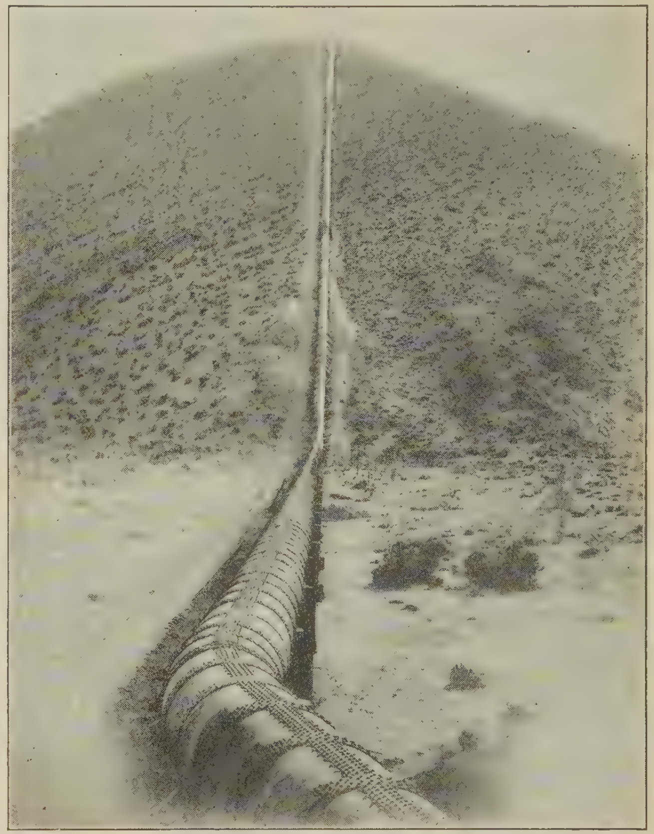
Series Synchronous Condensers for Transmission-Line Regulation, T. H. Morgan, Stanford University.

September 7 and 8

Trip to Mount Lowe.
Trip to Catalina Island.
Other trips as requested.

Trips

Automobile transportation will be furnished for trips to points of interest at all times except during convention sessions. For Wednesday, September 5, no sessions are scheduled and the entire day will be devoted to trips and sports. Trips have been arranged also for Saturday, September 7. The special trips are as follows:



Jawbone Siphon Section of 250-Mile Aqueduct Along which the City of Los Angeles has Constructed Five Power Plants and is Generating 166,000 Hydroelectric Horsepower

September 5

Long Beach Steam Plant No. 3, Central Receiving Station, Lighthipe Substation, Seal Beach Steam Plant, and Wilmington Receiving Station.

Los Angeles Hydroelectric Plant; San Fernando Mission; and Pacoima Flood Control Dam.

San Bernardino Substation; Glenwood Mission Inn, Riverside; Hotpoint Factory at Ontario.

California Institute of Technology, Million-Volt Laboratory; and University of California at Los Angeles.

September 7

Mount Lowe, via Pacific Electric R. R., round trip $3.00.

Power Plant and Substation Trips as requested.

SEPTEMBER 7 AND 8

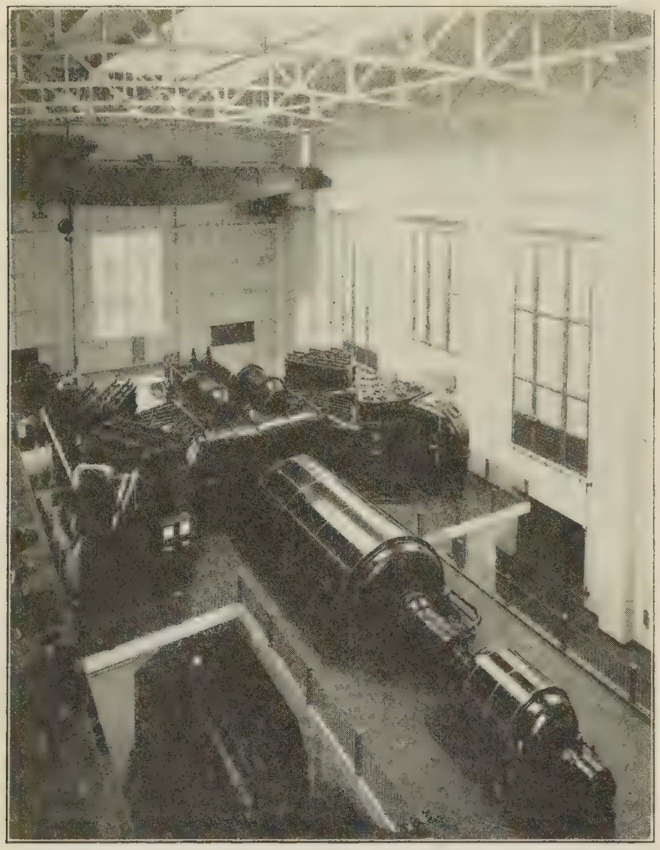
Catalina Island Trip,—all expenses paid including four meals and room at the St. Catherine Hotel—$12.50. Transportation only—$3.75.

Agua Caliente Trip,—visiting also Tijuana and San Diego. Transportation $10, if 20 or more go.

Trips will also be arranged to moving picture studios and if possible delegates will have the opportunity of seeing a talking picture in the making. Definite arrangements regarding studio trips will be announced later.

Golf

A golf tournament will be played at the Brentwood Country Club, which is a short distance from the Miramar and is considered one of the finest on the Coast. There will be numerous prizes for different classes of both low net and low gross scores; also the tournament will be played in classes, probably from scratch to 16, 16 to 24, and 24 and over. There are numerous cups that will be played for, complete announcement of which will be made later.



94,000 KW. GENERATOR UNIT OF SOUTHERN CALIFORNIA EDISON COMPANY. LONG BEACH

Arrangements have also been made whereby guests may receive cards to practically all the leading clubs, such as the Los Angeles Country Club, Brentwood, Rancho, Bel-Air and Riviera.

Ladies Entertainment

Many enjoyable events have been planned for the entertainment of the ladies. On Tuesday, September 3 the visiting ladies will be taken in automobiles to interesting points in and around Los Angeles.

On Wednesday at noon there will be a ladies luncheon to honor Mrs. E. R. Northmore, with Mrs. H. L. Caldwell presiding.

Wednesday afternoon will be devoted to an informal reception with tea and cards, either at the Miramar Beach Club or at the Hotel.

On Thursday morning a ladies' putting contest will take place. Other features are being arranged. Motion picture studio trips will be taken and the ladies will have the use of the Miramar Beach Club at all times.

Hotel Accommodations

Hotel reservations should be made directly with the Miramar Hotel, Santa Monica, Calif., Morgan S. Tyler, Resident Manager. Hotel rates are as follows:

For rooms in the main building and the cottages the rate is $3.50 per person per day This rate is on the basis of double rooms with bath. The rooms are extra large. Double suites in the Annex will accommodate three or four, and single suites will accommodate two people, each suite with bath. The rates in the Annex are $3.00 per person per day.

The charges for meals are as follows: Club breakfast, 25 cents to $1.00; Luncheon, $1.00 and Dinner, $1.50. There is also a la carte service at reasonable prices.

The regular club privileges to the Miramar Beach Club will be extended to all guests at the convention, the only charge being for the rental of bathing suit and locker for use in surf bathing or in the heated salt-water pool. For convention delegates the rate will be 50 cents per person.

Railroad Rates

Summer excursion rates will be in effect at the time of the convention and those who attend may have the benefit of considerable reductions from the regular railroad fare.

Committees

A large local committee is actively engaged in completing arrangements. E. R. Northmore, Vice-President of the Institute in the Pacific District, is Convention Chairman, and H. L. Caldwell, Chairman of the Los Angeles Section is Assistant Convention Chairman. The chairmen of the various sub-committees are as follows: *Registration*, G. E. Nott; *Entertainment*, R. A. Hopkins; *Transportation*, H. H. Cox; *Hotels*, F. E. Dellinger; *Ladies Entertainment*, L. C. Williams; *Program*, (*Members*) E. R. Stauffacher, *Program* (*Students*) R. W. Sorensen; *Finance*, N. B. Hinson; *Publicity*, J. H. Cunningham; *Golf*, Harold Thrane.

STANDARDS

Three New Reports on A. I. E. E. Standards Available

The attention of the membership is again called to the availability of three reports on proposed A. I. E. E. Standards. The reports may be obtained without charge by addressing the Secretary of the Standards Committee at Institute headquarters. They are No. 2, Electrical Definitions and Symbols; No. 12, Constant Current Transformers; No. 27, Switchboards and Switching Equipment for Power and Light. A detailed statement regarding these proposed Standards appears on page 565 of the July JOURNAL.

Specifications for Weatherproof Wires and Cables

A subcommittee of the Sectional Committee on Insulated Wires and Cables has prepared a draft of proposed specifications on the above project. This draft also contains a section on Heat-Resisting Wires and Cables. The work of this committee is under the chairmanship of Mr. Thomas Sproule of the New Jersey Public Service Corporation. Copies of the draft are available at American Standards Association office, 33 West 39th St., New York, for loan to those interested.

This report takes up in detail the covering, size of conductor, and the saturating compound for weatherproof wires. The drip, bending, and melting tests of the saturated cable are explained in some detail. The draft contains a table of weights given in pounds per 1000 ft. of cables varying in size from 250,000 to 1,500,000 cir. mils.

The section relating to Heat-Resisting Wires and Cables gives the Flame Proofing Test and other material on fire proof cable.

Dry Cells

The Sectional Committee on this project is preparing revisions which relate to the American Standard C 18-1928 and to U. S. Government Master Specifications for Dry Cells and Batteries No. 58a. A recent meeting of a subcommittee held in Cleveland recommended tests for industrial flashlight cells, and for radio B batteries, and that a study be made for six months with a view to changing the existing minimum required performance figures for batteries other than radio B batteries. In the latter connection some of the proposed changes are:

		Present	Proposed
General purpose cells No. 6	Heavy intermittent	50 hours	60 hours
General purpose cells No. 6	Light intermittent	160 days	170 days
Telephone Cells	Light intermittent	190 days	220 days
Radio A Cells	Light radio test	210 hours	225 hours
Flashlight Cells C	Intermittent test	170 min.	210 min.
Flashlight Cells C	Delayed Service three months	70 min.	80 min.
Flashlight Cells E	Intermittent Test	650 min.	750 min.
Flashlight Cells E	Delayed Service six months	420 min.	450 min.

Mr. G. W. Vinal of the Bureau of Standards, Washington, D. C., is Chairman of the Sectional Committee in charge of the revision of this standard, and comments or criticisms may be sent to Mr. Vinal.

Symbols for Photometry and Illumination

The sectional committee on Scientific and Engineering Symbols and Abbreviations has submitted to the sponsors a draft of a proposed standard developed by a subcommittee under the chairmanship of Mr. Frank Benford, Illiminating Engineering Laboratory, General Electric Company.

This draft, covering symbols for photometry and illumination, consists of 15 symbols covering such terms as radiant flux, quantity of light, and reflection factor. Copies of this draft are available for loan to those interested through the American Standards Association headquarters, 33 West 39th Street, New York.

The American Standards Association

In view of the fact that the first meeting of the Board of Directors of the American Standards Association was held on July 9 a short review of the history and purposes of this organization may be of interest.

American Engineering Standards Committee was set up in 1917 by a group composed of the A. I. E. E., the A. S. M. E., the A. S. C. E., the A. I. M. E., and the A. S. T. M., to provide a systematic method of bringing about the cooperation of bodies engaged in standardization; to prevent duplication; to determine whether new projects should be undertaken; and to ultimately affix the stamp of "American Standard" to completed projects after a thorough examination has shown such action warranted.

To keep in step with the rapid increase in industrial standardization, the American Standards Association, or as it was originally called theAmerican Engineering Standards Committee was reorganized in 1928. At the time of the reorganization, the Association had grown to 37 member bodies, with an additional three hundred and fifty sustaining members, including manufacturers, distributors, associations, etc. The reorganization has placed the technical work of approving standards in a "Standards Council" and concentrated the administrative and financial responsbility in a "Board of Directors" composed of twelve industrial executives. The underlying principles of the original A. E. S. C. remain unchanged. The basic functions remain completely in the hands of the member bodies who name the individual members of the Board of Directors and of the Standards Council. The present Board of Directors is composed of the following: Quincy Bent, Vice-President, Bethlehem Steel Company; G. K. Burgess, Director, Bureau of Standards; C. M. Chapman, Consulting Engineer; C. L. Collens, President, Reliance Elec. & Engg. Co.; Howard Coonley, President, Walworth Mfg. Co.; L. A. Downs, President, Illinois Central System; Bancroft Gherardi, Vice-President, American Tel. & Tel. Co.; F. E. Moskovics, President, Improved Products Co.; W. J. Serrill, Chairman of Research Committee, U. G. I. Co.; C. E. Skinner, Asst. Director of Engineering, Westinghouse Elec. & Mfg. Co.; M. S. Sloan, President, New York Edison Co.; R. J. Sullivan, Vice-President, Travelers Insurance Co.

An agreement has just been reached between the American Standards Association and the Bureau of Standards outlining the cooperative relation of the two bodies in reference to commercial standards. The National Bureau of Standards, through its Division of Trade Standards, is acting as a centralizing agency for industrial and commercial groups requesting its cooperation in the adjustment, application, and promotion of standards that will facilitate production and marketing of the commodities which concern the requesting group. After proper acceptance of such standards by the interests immediately concerned, the Bureau publishes them as the "Commercial Standards" of those interests. Primarily, the effort of the Bureau is to serve those groups which have no satisfactory standardization facilities. Since "Commercial Standards" are obviously of interest to groups immediately concerned with the manufacturing and marketing of specific commodities, such standards are not considered to have the same status as is imparted to standards approved as American Standards by the A. S. A., though it is hoped that some Commercial Standards will eventually receive such approval. Commercial standards are temporary standards.

Highway Research Board to Meet in December

The Ninth Annual Meeting of the Highway Research Board will be held December 12-13, in Washington, D. C., at the building of the National Academy of Sciences and National Research Council.

An important feature of the meeting will be the presentation of progress reports upon the comprehensive program of highway research now in preparation by the Board.

AMERICAN ENGINEERING COUNCIL

SPECIAL COMMITTEE TO WORK WITH CONGRESS AND FEDERAL ADMINISTRATION

Organization for 1929 of more than a score of committees to work with Congress and the Federal administration in shaping public policies involving vast engineering operations is announced by the American Engineering Council. Communications, flood control, safety of dams, water resources, and Government reorganization are among the chief problems to be studied.

At a meeting of the Council's Administrative Board to be held in Washington in October, these committees will submit reports reflecting the engineering attitude toward legislation arising at the next session of Congress.

With an engineer in the White House, and a growing representation of engineers in public posts,—national, state, and municipal,—the Council, according to an announcement by its President, Arthur W. Berresford, has framed what is believed to be the most helpful program of cooperation with public agencies in the history of American engineering.

The results, he adds, should enable the Government to function more intelligently in engineering projects requiring annually the expenditure of millions of dollars. Mississippi flood control is

cited as one of many situations which need clarification by the civil engineer.

D. Robert Yarnall of Philadelphia is Chairman of the Public Affairs Committee. Public questions affecting engineers generally will come before this Committee, other members of which have been chosen as follows: J. L. Hamilton, St. Louis; John Lyle Harrington, Kansas City, Mo.; H. A. Kidder, New York City; W. S. Lee, Charlotte, N. C.; R. C. Marshall, Jr., Chicago; Charles Penrose, Philadelphia; R. F. Schuchardt, Chicago; C. E. Skinner, East Pittsburgh, Pa.; Max Toltz, St. Paul, Minn.; Edwin F. Wendt, Washington, D. C.

A new Committee on Communications, to study proposed legislation for Federal supervision of such means of communication as radio, telephone, and telegraph, is headed by Edwin F. Wendt, of Washington. It will study fundamental questions raised by the Watson and Couzens Bills. Other members are: O. H. Caldwell, New York, Federal Radio Commissioner; Dean Dexter S. Kimball, Cornell University; Frank A. Scott, Cleveland; Charles B. Hawley, Washington, D. C.

Gardner S. Williams of Ann Arbor, Mich, is Chairman of a Committee on Flood Control. Mr. Williams also heads Committees on Government Reorganization and the Safety of Dams.

Chairmen of other Committees of the Council include:

Power—Farley Osgood, New York; Reforestation—William Boss, University of Minnesota; Street and Highway Safety—M. M. Fowler, Chicago; Recent Economic Changes—Dean Dexter S. Kimball, Cornell University; Engineering and Allied Technical Professions—H. C. Morris, Washington; Regional Activities, and Membership and Representation—O. H. Koch, Dallas, Tex.; Program of Research—Dr. Harrison E. Howe, Washington; Man-Hour Information, and Constitution and By-Laws—L. P. Alford, New York; Patents—Edwin J. Prindle, New York; National Hydraulic Laboratory—Farley Osgood, New York; Washington-Potomac Canal—D. H. Sawyer, Washington; Finance—John H. Finney, Washington; Representation—A. W. Berresford, New York.

NICARAGUAN INTEROCEANIC CANAL BOARD APPOINTED

By authority received from the Edge Resolution, Publ. Res. 99, of the 70th Congress, President Hoover has appointed a Nicaraguan Interoceanic Canal Board composed of the following five members:

General Edgar Jadwin, Chief of Engineers, U. S. A., Chairman; Major Ernest Graves, U. S. Engineers; Doctor Anson Marston, President, American Society of Civil Engineers; Frank M. Williams; and Sidney B. Williamson. Three members of this board are engineers from civilian life, and four are members of the American Society of Civil Engineers, a member organization of American Engineering Council. Lieut. J. P. Dean has been chosen Secretary to the Board.

Not only will the Board investigate the feasibility, desirability, and cost of increasing the facilities of the Panama Canal, but it will investigate and bring up-to-date the data on the Nicaraguan Canal route and any other routes considered in the opinion of the Board worthy of consideration.

Costa Rica and Nicaragua have given their consent to the preliminary surveys and operations of the troops and survey parties within their territories for this purpose. President Hoover has authorized the dispatch to Nicaragua of a battalion of engineer troops to make the investigation and survey.

PLEA FOR MAPPING APPROPRIATIONS

At the last meeting of the Administrative Board of American Engineering Council, a plea for increased appropriations for mapping facilities was again instructed. Hon. Robert P. Lamont, Secretary of Commerce, and Hon. Ray L. Wilbur, Secretary of Interior, were approached, having the work of the Coast and Geodetic Survey and the Geological Survey, respectively, coming under their jurisdiction.

In order to secure efficient and economic operation of all major engineering projects, including city surveys and planning, highway development and extension, irrigation projects, hydroelectric developments, improvement of rivers for navigation, flood control of rivers, and general topographic surveying and mapping, a knowledge of elevations and geographic positions is required.

According to the Board of Surveys and Maps of the Federal Government the completion of the fundamental leveling and triangulation needs of the country has been estimated to cost not in excess of five million dollars.

In the plea to the Secretary of Interior in behalf of the topographic survey American Engineering Council urged that hereafter the appropriations for topographic surveys be increased annually so as to complete the work of topographically mapping the United States in a period of 25 years as contemplated and authorized by the Temple Act, as it believes that the Federal Government engages in no more important work than that of making available accurate topographical maps.

COLORADO RIVER PROJECT PROGRESSES

As required by the Boulder Canyon Project Act, approved December 21, 1928, President Hoover has issued a public proclamation that all prescribed conditions have been fulfilled, and that the act is effective as of June 25, 1929. At the time of the signing of this proclamation, President Hoover stated that difficulties over the respective water rights of the different States have served to prevent development in a large way for nearly a quarter of a century. He considers this "the most extensive action ever taken by a group of States under the provisions of the Constitution permitting compacts between States," and hopes that Arizona and California may compose their mutual problems which have hitherto prevented Arizona from joining in the compact, for "with Arizona in, the whole Basin will have settled its major question of water rights for all time."

Secretary of the Interior Wilbur, in an address at Las Vegas, Nevada, on June 22, enunciated a new government policy with reference to the Colorado River project, stating that he would like to see the government come in and build reclamation projects, protect its investment through contracts that will pay the money back into the treasury and then withdraw from the field; not to become involved in situations purely local or those calling for intricate settling of tax problems and bond issues, or community and states rights.

L. C. Hill, A. S. C. E.; A. J. Wiley, A. S. C. E.; and W. F. Durand, Past-Pres., A. S. M. E., were chosen to act as special consultants in the field service of the U. S. Bureau of Reclamation in connection with the development of the Boulder Canyon Dam project.

Further information concerning the project may be secured by addressing the Commissioner of Reclamation, Washington, D. C.

WATER RESOURCES DIVISION NEEDS HELP

It has been the function of the U. S. Geological Survey since 1888 to systematically collect and make available data in regard to the water resources of the nation. This is an exceedingly useful service, and the only criticism which has been expressed has been that a sufficient amount of information has not been collected and made available. This has been due to insufficient appropriations by the Federal Government. The amount of work which has been completed to date would not have been realized had not State and local governmental agencies, individuals, and corporations supplied the U. S. Geological Survey with funds in addition to those appropriated by the Federal Government.

The Western Association of State Engineers, with a membership composed of 17 western States, has expressed itself in favor of the policy enunciated, and has designated American Engineering Council as its agent in regard to this matter.

A. I. E. E. Directors Meeting

The regular meeting of the Board of Directors of the American Institute of Electrical Engineers was held at the New Ocean House, Swampscott, Mass., on Tuesday, June 25, 1929, during the annual Summer Convention of the Institute.

There were present: President R. F. Schuchardt, Chicago, Ill.; Vice-Presidents: E. B. Merriam, Schenectady, N. Y.; J. L. Beaver, Bethlehem, Pa.; H. A. Kidder, New York, N. Y.; W. T. Ryan, Minneapolis, Minn.; O. J. Ferguson, Lincoln, Neb.; B. D. Hull, Dallas, Tex.; E. R. Northmore, Los Angeles, Calif.; A. B. Cooper, Toronto, Ont.; Directors: A. E. Bettis, Kansas City, Mo.; H. C. Don Carlos, Toronto, Ont.; F. C. Hanker, East Pittsburgh, Pa.; A. M. MacCutcheon, Cleveland, Ohio; E. B. Meyer, Newark, N. J.; C. E. Stephens, New York, N. Y.; National Secretary F. L. Hutchinson, New York, N. Y. Also present, by invitation: Past-President Charles F. Scott, New Haven, Conn.; Officers-elect: Harold B. Smith, Worcester, Mass.; W. S. Rodman, Charlottesville, Va.; W. S. Lee, Charlottee, N. C.; J. E. Kearns, Chicago, Ill.; Assistant National Secretary H. H. Henline, New York, N. Y.

The minutes of the Directors meeting of May 22, 1929, were approved as previously circulated.

A report of a meeting of the Board of Examiners held June 19 was presented and the action taken at that meeting were approved. Upon the recommendation of the Board of Examiners, the following actions were taken upon pending applications: 147 Students were enrolled; 195 applicants were elected to the grade of Associate; 19 applicants were elected to the grade of Member; 74 applicants were transferred to the grade of Member; five applicants were transferred to the grade of Fellow.

Approval by the Finance Committee for payment of monthly bills amounting to $50,759.51 was ratified.

The following were exempted from future payment of dues as "Members for Life," in accordance with Sec. 22 of the Constitution: F. F. Barbour, E. A. Barnes, W. H. Brenner, H. F. Parshall, L. A. Phillips, Norman N. Ross, George F. Sever, A. E. Worswick.

Approval was given to the date, May 7-10, 1930, selected by the District Executive Committee, for the already authorized meeting in the North Eastern District to be held at Springfield, Mass.

Upon the recommendation of the Chairman of the Sections Committee, the Board acted favorably on a request of the Oklahoma Section and authorized a change in name of that Section to "Oklahoma City Section," and authorized a new Section, comprising the entire state of Iowa, to be known as the "Iowa Section."

Approval was given to the organization of a Student Branch of the Institute at the Michigan College of Mining and Technology, Houghton, Mich., which was recommended by the Committee on Student Branches.

The following were elected Honorary Members of the Institute: Herbert Hoover, Charles F. Brush, (posthumously), and Charles F. Scott.

The following minute in memory of Charles F. Brush was adopted:

On June 15, 1929, through the death of Charles Francis Brush, there was removed from the ranks of the Institute, one of its charter members. Over a period of almost seventy years of activity his name has ever been in the forefront as a pioneer in electrical development work. One of the first to realize the value of the work of Gramme, in 1876 he designed and built a dynamo. In 1878 he exhibited the first of the world famous Brush arc light machines. Scientist, engineer, humanitarian and philanthropist, recipient of world wide honors, Edison Medalist—the Board of Directors of the American Institute of Electrical Engineers wishes to have it recorded that as a mark of appreciation of his services to the profession, Doctor Brush was, at the time of his death, though in accordance with proceedings instituted months before, about to be awarded Honorary Membership, and record of election to Honorary Membership by the unanimous vote of all the members of the Board of Directors is hereby made. Further, the Board of Directors extends to his family and associates its sincere sympathy.

Decision was made to appoint a Local Honorary Secretary of the Institute for Russia, and Doctor Michael Chatelain was appointed for the term of two years beginning August 1, 1929.

A recommendation made at the Conference of Officers and Delegates, June 24, was presented and adopted, that regional meetings hereafter be referred to as "District Meetings." A recommendation made at the same conference that the appropriation year for Sections begin August 1 instead of October 1, was referred to the Finance Committee, with the understanding that if feasible, this change will be put into effect August 1, 1929.

Resolutions were adopted expressing the Board's appreciation of the effective services rendered by the General Convention Committee, its various subcommittees, and the Ladies Committee, in connection with the annual Summer Convention, Swampscott, Mass., June 24-28.

Other matters were discussed, reference to which may be found in this and future issues of the Journal.

The meeting closed with an expression by President Schuchardt of his appreciation of his exceedingly pleasant association with the members of the Board during his administration, and a unanimous vote of appreciation of the members of the Board of the valuable services rendered to the Institute during the past year by President Schuchardt.

Honorary Members Elected

Three distinguished American Engineers were elected Honorary Members of the American Institute of Electrical Engineers at a meeting of its Board of Directors held June 25 during the Annual Summer Convention of the Institute in Swampscott, Massachusetts.

The men thus honored were:

Herbert Hoover, most outstanding American engineer.

Charles F. Scott, engineer and inventor, head of the Electrical Engineering Department of Yale University, Past-President of the Institute.

Charles F. Brush, Cleveland, Ohio, engineer and scientist, recipient of Edison Medal, whose death occurred on June 15, at which time he was being balloted upon. The unanimous vote of the Directors of the Institute having been received, the Directors voted on June 25 to record Doctor Brush's name in the list of Honorary Members.

Five other Americans and three representatives of foreign countries had previously been elected as Honorary Members of the Institute. The Americans are John J. Carty, Thomas A. Edison, Michael I. Pupin, Ambrose Swasey, and Elihu Thomson.

Section and Branch Activities

President Smith in his message on the front page of this issue of the Journal places much emphasis upon the importance of the third object of the Institute, *i. e.*, "the development of the individual engineer" and the functions of the Sections and Branches in carrying the Institute life with its opportunities for active service to the profession to within a reasonable radius of the individual wherever he may be located.

In accordance with this policy of carrying the life and support of the Institute to the individual, as outlined in his message, President Smith is attempting a personal appearance and talk before the membership of each of the fifty-six Sections of the Institute this year. It is hoped that, wherever possible, each of the 101 Branches may unite with the appropriate and nearest Section for these meetings, as these talks are designed especially for the younger membership of the Institute.

The Annual Report on Section and Branch Activities, issued in pamphlet form in June and mentioned in his message, contains an extended resume in summary and statistical form of their principal activities during the fiscal year ending April 30, 1929. The information presented makes clear the facts that the activi-

ties of many Sections and Branches have been greatly improved and that there is deep interest among the officers of the local groups in finding methods which will offer the greatest benefits to the individual members. A considerable amount of space is devoted to cooperation between Sections and Branches. Copies of this Report may be secured without charge upon application to Institute headquarters.

In order to indicate briefly the rapid increase in Section and Branch activities during the past few years, a table which appeared in the Annual Report of the Board of Directors for the fiscal year ending April 30, 1929, is reproduced below.

	For Fiscal Year Ending			
	April 30 1923	April 30 1925	April 30 1927	April 30 1929
SECTIONS				
Number of Sections	46	49	52	54
Number of Section meetings held	344	386	431	460
Total Attendance	46,672	49,029	60,708	73,254
BRANCHES				
Number of Branches	68	82	95	100
Number of Branch meetings held	503	548	842	940
Total Attendance	26,893	27,603	42,650	47,408

Lamme Medal Presentation

The first (1928) Lamme Medal which was awarded to Allan B. Field, as reported in the February 1929 issue of the JOURNAL, was presented to him during appropriate ceremonies at the banquet meeting held on Wednesday evening, June 26, at the Summer Convention at Swampscott. This award was made for "the mathematical and experimental investigation of eddy-current losses in large slot-wound conductors in electrical machinery."

Past-President Charles F. Scott, Chairman of the Lamme Medal Committee, conducted the program during which the presentation was made, and in his opening address spoke briefly upon the significance of the Medal and the characteristics of Benjamin G. Lamme, the founder. A sketch of the career of Mr. Lamme was given by N. W. Storer, who was closely associated with him for many years, and the achievements of the recipient were summarized by B. A. Behrend, with whom Mr. Field was associated at the time he did the work for which the award was made.

Following the presentation of the Medal and a certificate by President Schuchardt, Mr. Field responded with a short address.

At the conclusion of the Lamme Medal presentation program, Professor Scott announced that by a remarkable coincidence, another medal had been awarded to Mr. Field for the same achievement, and the John Scott Medal, awarded by the Board of City Trusts of Philadelphia, accompanied by a check for $1000 and a certificate, was presented to him by F. L. Hutchinson, National Secretary. Mr. Field responded briefly.

Kelvin Medal Awarded to Andre Blondel

At a meeting of the Kelvin Medal Award Committee held in London on the 21st of June, the fourth triennial Kelvin Medal was awarded to Monsieur André Blondel, Membre de l'Academie des Sciences, Membre de l'Institute de France, Officier de la legion d'Honneur, President d'Honneur de la Societe Francaise des Electriciens, Inspecteur General des Ponts et Chaussees, and Honorary Member of the American Institute of Electrical Engineers—he, being in the opinion of the Committee, after consideration of the representations received from leading engineering bodies in all parts of the world, the most worthy to receive on the present occasion this mark of distinction in engineering work and investigation of the kinds with which Lord Kelvin was especially identified.

Colloquium on Power Circuit Analysis

HELD AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY

A colloquium on Power Circuit Analysis with Particular Reference to the Behavior of Machinery and Transmission-Line Stability, was in session at the M. I. T. from June 10 to June 22, 1929. A committee was established to formulate conclusions and recommendations, if possible, and to make suggestions regarding further investigations which might be desirable.

At the final session the report of the committee, with certain modifications, was accepted and some of the items of the report were released for publication in the technical press in the belief that they would be of service to the electrical engineering profession at large.

The colloquium was attended by about 80 representatives of prominent electrical manufacturers, constructing and engineering organizations, electric light and power companies, and technical educational institutions. The conclusions made public are as follows:

CONCLUSIONS AND SUGGESTIONS OF THE COLLOQUIUM

Method of analysis. It is sometimes expedient to assume constant impedances, similarity of direct and quadrature axes, constant linkages, and constant shaft torque. If this be done, and if there are only a few important machines or stations involved, steady-state stability analyses may be made by very simple analytic methods or by the method of mechanical equivalents. Transient analyses involving two machines may be very simply made by the equal-area method. If there are more than two machines the step-by-step method is still relatively simple as a result of these assumptions. The method of mechanical equivalents is also available here. These methods have been described in the literature and will in many cases give accuracies comparable with the accuracy of the data involved and the importance of the matter under consideration. When more accurate or more complete methods are necessary the following are available:

I. Steady State.
   The chart method with or without the help of the network analyzer.

II. Transient State.
   1. Step-by-step method.
      (a) Analytical.
      (b) Aided by the circle diagram.
      (c) Aided by the network analyzer.
   2. Integraph method.
      The integraph is especially suitable for the detailed investigation of the effect of variations in particcular machine characteristics; for example, the determination of the effect of excitation systems, amortisseur windings, and the duration of fault.

In any of these methods unbalanced conditions may be reduced to balanced equivalent circuits by the method of symmetrical components.

It is to be emphasized that the results of any method of analysis can be no more accurate than the original data used.

Definitions. The need for a better-established terminology for use in stability studies is recognized, and it is felt that the following steps to establish this terminology are desirable:

(a) It is recommended that the manufacturers of equipment initiate a move for making uniform and definite the terms used in specifying such quantities as exciter response, the reactances of machines, the inertia constant, time constants, damping torque, and reluctance torque.

(b) It is recommended that a communication be addressed to the proper committees of the American Institute of Electrical Engineers and of the National Electric Light Association, stating the need for explicit definitions of certain terms used in stability studies such as static-sta-

bility limit, transient-stability limit, and dynamic or artificial stability.

Further Investigations. The discussion of this colloquium has brought out the need for further analysis and experimentation along many lines, and the following specific lines of investigation and publication of results are recommended:

(a) A study of the effects of saturation in synchronous machines during transient conditions.

(b) Further information in regard to the performance of turbine governors under transient conditions.

(c) Further study of the conditions causing hunting in systems.

(d) Transient power limit tests on life-sized or actual systems and machines for determining the effects of important characteristics such as regulator characteristics, exciter speeds, constants of the amortisseur windings, and breaker time.

(e) Further information in regard to the characteristics of actual loads. This requires the development of methods of determining load characteristics.

(f) Further tests and the development of methods of calculating the impedance of circuits which include ground return.

(g) Further study of the value of different methods of system grounding from the standpoint of system stability.

(h) More complete and accurate records of system troubles, with all necessary data, including such as are obtained by automatic recording oscillographs.

(i) An investigation of the economic value of modifying generator reactance.

(j) Studies explaining the region of applicability and the relative accuracy of the various methods of analysis.

Journal of Engineering Science. The colloquium membership wishes to state that it feels the need for a new journal of engineering science in which material of a highly technical character, such as that listed under the heading, "Further Investigations," can be published more fully than is possible with existing journals.

PERSONAL MENTION

G. B. Pulham, Chief Erecting Engineer for India, Burma, and Ceylon for Metropolitan Vickers Electrical Co., Ltd., returns to Calcutta from England this month.

Justin J. McCarthy has been appointed Sales Engineer of the Sheffler-Gross Company, Inc., 203-11 Drexel Building, Philadelphia, sales agents for heating, ventilating, and power plant equipment.

W. H. Kretz has been appointed to the Transformer Sales Division of the Wagner Electric Corporation, St. Louis. He was formerly Texas district representative for the Jeffery-De Witt Insulator Company.

Harold B. Smith, President of the Institute and professor of Electrical Engineering at Worcester Polytechnic Institute, had two honorary degrees of Doctor of Engineering conferred upon him in June of this year by Purdue University and the Worcester Polytechnic Institute.

Lester R. Sellers, who for nearly three years has been in the employ of the Station Engineering Department of the Philadelphia Electric Company, Philadelphia, Pa., has now engaged with the Western Electric Company in the Plant Engineering Department of its Hawthorne Station.

R. Harland Horton has been appointed ExecutiveDirector of the Philadelphia Business Progress movement which has been organized to operate for three years. Mr. Horton was previously Vice-President of Operations for the Mitten Management. More than $1,350,000 will be expended in the new development.

J. Verling Walrod, who has been Assistant to the Chief Engineer of the Minneapolis-Honeywell Regulator Company, Minneapolis, Minn. has now joined the Research and Engineering Department of the Time-O-Stat Controls Company, Elkhart, Indiana, in connection with inspection, testing and development work upon new and contemplated products.

E. P. Dillon has been appointed Vice-President and Associate Engineer of the E. Y. Sayer Engineering Corporation, Knickerbocker Building, New York, designers and builders of power and industrial plants. For the past ten years Mr. Dillon has been General Manager for the Research Corporation of New York, in charge of sales of the Cottrell processes of electrical precipitation. He joined the Institute in 1902.

A. R. Robison, who has been Construction Superintendent for the United Gas and Improvement Company, Philadelphia, has been elected Vice-President and General Manager of the Toledo, Bowling Green & Southern Traction Power Company, Findlay, Ohio; the North Baltimore Service Company; the Rudolph Light & Power Company, and the Wooster Electric Company,—all in Ohio. These companies are a part of the Empire Public Service Company's system. Mr. Robison has also been elected to the same office with the Western Ohio Railway & Power Corporation.

Obituary

William Symes Andrews, who for over fifty years has been a representative figure in the electrical world and a man to whom Thomas A. Edison perhaps owes more than to anyone else in the development of the incandescent lamp, died at his home in Schenectady, July 1, 1929. He was but seven months younger than Mr. Edison, and his half-century period of service with him, in Mr. Edison's own words, was fraught "with many pleasant recollections, great interest, and satisfaction."

Mr. Andrews was born in Saltford, England, the son of Bailey and Selina (Chesterton) Andrews. He attended Cuzner's Collegiate Academy at Beckington, near Bath, where he evidenced great aptitude in electrical and scientific matters. After graduation, he was made an instructor in the academy, and so thorough was his knowledge in the scientific field that when only 18 years of age, he became head master of the school, a position which he held for ten years.

In 1875 he removed to Toronto to enter the firm of Raybon & Company, manufacturers of firearms and sporting goods. Two years later, he established a branch factory for the firm in Newark, New Jersey, he himself becoming superintendent. In November 1879 he joined Mr. Edison at Menlo Park in his development of the invention of the incandescent lamp. He assisted in winding the armature of Edison's first dynamo, constructed the first Edison chemical electric meter, molds for carbonizing the filaments of the lamps, and ultimately, the diminutive and delicate mechanisms for picking up the hair-like filaments and placing it between platinum clamps for mounting. Early in 1881, Mr. Edison conducted a test on 600 of his electric lamps, upon which tests depended the decision for their commercial efficiency. It was made Mr. Andrew's responsibility to scrutinize the performance of certain test control apparatus and to regulate it as required. In his ardor over the situation, he worked fifty hours without sleep. On October 8 of that year he was made Superintendent of the Testing Department at the Edison Machine Works, Newark. Two years later in June he became Chief Electrical Engineer of the Central Station Construction Department of the Edison Electric Light Company, during the next three years establishing over thirty local Edison generating stations including those at Sunbury, Pennsylvania—the first Edison three-wire station in the United States; Rochester, New York; Des Moines, Minneapolis, New Orleans, and Chicago. In 1894, Mr. Andrews went to Schenectady to enter the employ of the General Electric Company, and from 1897 to 1903 he was engaged in X-ray testing, taking out a number of patents on methods of testing and regu-

lating X-ray tubes. In fact, it is undoubtedly true that he died a martyr to scientific development due to the effects of X-ray burns sustained over a prolonged period of thirty-five years' investigation, at a time when, because of its comparative infancy, the whole danger of the properties of X-ray was not understood. The subject of illumination by phosphorescence and fluorescence was also of great interest to him. In 1913 he was made Consulting Engineer for the company, a post he held at the time of his death.

When in the Spring of 1922 active steps were taken to gather and preserve the relics of early Edison days, now forming our Historical Electrical Collection, it was Mr. Andrews who responded at once to the call, and through the kindness of the General Electric Company, was permitted to devote a great deal of his time to aiding, and giving all the benefit of his experience.

Mr. Andrews became an Associate of the Institute in 1889; he was elected a Fellow in 1912, and was made a Member for Life October 1926. He was a Fellow also of the Illuminating Engineering Society, a Member of the American Association for the Advancement of Science, the National Electric Light Association, the Franklin Institute of Philadelphia, the Historical Society of Pennsylvania, and the Edison Pioneers. F. A. Wardlaw, Secretary of the Edison Pioneers, in his tribute to Mr. Andrews says, "Endeared as he was to scientists and technicians for his many contributions to theory and practise, he was equally endeared to all whose privilege it was to really know him, as a man of lovable character, and sterling integrity, seeing the good, and only good, in every situation by which he was confronted. The superlative spartanism which he exhibited throughout his years of illness,—in fact throughout his entire life,—will long remain a cherished memory."

Eugene H. Abadie, Consulting Engineer, Washington, D. C., and prominent in the profession for a great many years, was killed at the wheel of his automobile in collission with a telegraph pole April 27. On his way to his golf club, he swerved his car to escape another which had swung from the curb, and in the suddenness of the action he lost control of the car and it crashed, injuring him so vitally that he died on the way to the hospital.

Colonel Abadie was a Life Member of the Institute, which he joined in 1905. He was a native of St. Louis, Missouri, where, after finishing high school, he was graduated from the St. Louis Manual Training School. He entered Washington University, but did not graduate, leaving to accept an attractive offer made him by Herbert A. Wagner to join him in building up a company just then incorporated—the Wagner Electric Mfg. Company.

For a period of six months Mr. Abadie worked in the shops; later he divided his time between the shops and the office. The latter part of 1892 he was given the active management of the Company's business with the title of Manager of Sales. Continuing in this capacity until 1900, he formed an organization for the control of the output of the Bullock Electric Mfg. Co. and the Wagner Electric Company. He was immediately chosen Manager and the following year he was one of the incorporators of the Wagner Bullock Electric Company of California, which during its first year he served in the capacity of Vice-President. In 1902 he established his own company under a partnership name of E. H. Abadie & Company, for general engineering and contract work of which there was a superabundance at that time in the Middle-Western and Southwestern states. For a while he was affiliated with the Elblight Company of America, in an effort to reorganize. When he removed from St. Louis to Washington, D. C., he established a consulting engineering office of his own, with which he was occupied at the time of his death.

Mr. Abadie joined the Institute in 1905 as an Associate and was transferred to Member in 1913. He was a Director as well as a Charter Member of the American Society of Engineering Contractors; a Member of the Engineers' Club of St. Louis; a Member of the League of Electric Interests of St. Louis and of the Jovian Order.

William O. Winston, Jr., Vice-President and Director of the Winston Brothers Company, Minneapolis, and an Associate of the Institute since 1915, died at the age of 43, June 18 on the Pacific Coast, after a short illness.

Mr. Winston was a student in Electrical Engineering at Cornell University from 1908 to 1911, when he became foreman of the ore mine work of the Winston Brothers Company at Hibbing, Minn. The following year he went to Hersey, Wisconsin, as the agent of that company there and at Great Falls, Montana, later to be given charge of small lighting plants used in construction work at Malta, Mont. In 1914 he removed to Junction, Colo. At the time of his death he was in charge of Grand construction of the Diablo Dam on the Skagit River, a unit in the hydroelectric development for the city of Seattle.

Thomas Edward Murray, who for many years was in charge of all the allied Edison companies in New York and Brooklyn, and subsidiaries in Westchester County, and to whom, next to Thomas A. Edison, have been granted more patents than to any other inventor in the United States died the morning of July 21 at his summer home, Wickapogue, Southampton, after an illness which has extended over several months.

Mr. Murray was sixty-nine years old. He was born at Albany, New York, and attended the public and private night schools there for nine years, for two years doing additional work in the drafting room of local architects and engineers. For four more years, he served an apprenticeship as machinist in the shops of the Albany Iron & Machine Works. In 1881 he entered the employ of the Albany Water Works as Operating Engineer, remaining in that capacity until 1887, when he became Chief Engineer, Superintendent and then General Manager for the Albany Electrical Illuminating Co. From 1890 to 1900, he was Consulting Engineer for the Albany Railway Co., the Troy City Railway Company, the Troy Electirc Light Company and the United Traction Company (Albany and Troy); and from 1899 he was Consulting Engineer for the Kings County Electric Light & Power Company and the Brooklyn Edison. He was also General Manager of the New York Gas and Electric Light, Heat, and Power Company from its incorporation date.

At an early age he established a reputation as an expert machinist and attracted the attention of the late Anthony N. Brady, who was then entering the field of public utilities. Mr. Murray was placed in charge of the Municipal Gas Company of Albany, and while holding that post his inventive genius, which was to yield him a record of over 1100 patents, began to assert itself. While he was still very young, Mr. Brady sent him to New York to organize and purchase all electric franchises in New York and Brooklyn. This resulted in the Edison Electric Illuminating Company of Brooklyn, which afterward was called the Brooklyn Edison Company, Inc. His work in New York led to the formulation of the New York Edison Company and the United Light and Electric Light Company. Upon consolidation of these interests, Mr. Murray was placed in complete charge of all allied Edison Companies, as well as the outlying subsidiaries. Last year, because of ill health, he was forced to resign from the vice-chairmanship of the Board of the New York Edison Company, but he continued to maintain a general supervision of his own corporations, the Metropolitan Engineering Company, the Metropolitan Device Corporation, the Murray Radiator Company and Thomas E. Murray, Inc. He was also a Past-President of the Association of Illuminating Companies.

Notwithstanding the fact that most of his earlier work was in the electrical and gas appliance fields, the force of his activities has been felt in almost every phase of modern industry. For innumerable inventions of safety applicances, he has received the Lonstreth Medal from the Franklin Institute of Philadelphia; during the World War, his method of welding shells was productive of the 240-mm. mortar shell, winning him high commendation from the War Department. In his consulting engineering work he redesigned and directed the mechanical and electrical construction of the Troy Electric Light Company's plant the Troy

City Railway's plant, including rotary substations of the United Traction Company, and designed and directed the construction of the Kings County Electric Light & Power Company's station in Brooklyn. Mr. Murray joined the Institute in 1901 and became a Fellow in 1912. He was also a prominent member of the American Society of Mechanical Engineers.

Ferntagung Meeting By Long Distance Telephone

The electrical industry was well represented at the thirty-fourth Annual Meeting of the Verband Deutcher Elektrotechniker at Aachen, Germany, July 8–9, 1929. Electrical societies of Germany, Holland, Austria, and Hungary participated in sessions held jointly by means of telephonic communication, and the feasibility of holding future joint meetings by telephone was clearly demonstrated.

The address of welcome was given by General Director Doctor E. M. Krone, of Dortmund, who, after greeting his guests and those in other countries taking part in the proceedings gave a forceful talk on the advancement made in the electrical industry during the past year. He was followed by E. L. P. Craemer, who discussed international long distance telephony. Short addresses followed by Professor Dr. Reithoffer, Electrotechnical Society, Vienna, Director Beekman, of the Royal Holland Institute, Division of Electrotechnik, in Hague, Holland, and last, Professor Carl Zipernowsky, of the Hungarian Electrotechnical Society, Budapest. Other speakers from the Hague, Vienna, and Budapest also spoke from their respective cities by telephone. The meeting closed Tuesday evening with a garden party.

A. I. E. E. Section Activities

SECTION ORGANIZED AT BIRMINGHAM, ALABAMA

At a meeting held in Birmingham on June 21, the Birmingham Section, which had been authorized by the Board of Directors on May 22nd, was organized. R. W. Lamar, Chief Engineer of the Birmingham Electric Company, was elected Chairman, and O. E. Charlton of the Engineering Department, Alabama Power Company, was chosen as Secretary.

Vice-President C. O. Bickelhaupt of the Southern District was represented at the meeting by S. A. Flemister. H. L. Wills, Chairman of the Atlanta Section, was present and gave a brief talk on the activities of the Institute. H. M. Woodward was elected Delegate of the Section to the Summer Convention at Swampscott, Mass.

PAST SECTION MEETINGS

Akron

The Engineers' Participation in Civic Affairs, by R. F. Schuchardt, President, A. I. E. E. Short addresses by L. G. Tighe, Ass't General Mgr., Northern Ohio Power & Light Co.; Henry Vance, Local Consulting Engr.; A. O. Austin, Chief Engr., Ohio Insulator Co., and W. A. Hillebrand, Chairman-Elect of the Section. Annual Meeting, joint with University of Akron Branch. Talk by C. D. Tinley, Chairman of the Branch. The following officers were elected for next year; Chairman, W. A. Hillebrand; Secretary, R. R. Krammes; Treasurer, N. Berthold; Chairman, Meetings & Papers Committee, H. C. Paiste; Chairman, Membership Committee, W. J. Secrest. May 24. Attendance 58.

Cincinnati

Engineers and Their Perspective, by W. E. Stilwell, Jr., and

Imprint of Engineering on Industry, by Retiring Chairman R. C. Fryer. Brief talks by Ted Hubbell, Embry-Riddle Co., on "Engineers and Aviation;" G. L. Tarrington, Electrical Research Products, Inc., on "Talking Movies," and Dr. B. A. Schwartz, Heart Specialist, on "The Electric Cardiograph." Secretary-Treasurer gave his annual report. Officers elected for next year are as follows: Chairman, T. C. Reed; Secretary-Treasurer, L. L. Bosch; Directors, L. O. Dorfman, E. S. Fields, W. E. Beatty, J. A. Noertker and H. D. Rei. Dinner guests at the Maketewah Country Club on invitation of Francis R. Healy. June 13. Attendance 53.

Detroit-Ann Arbor

Research on Wind Loading of Electrical Power Lines (in two parts): *Fundamental Theory and General Methods*, by Prof. R. H. Sherlock, University of Michigan, and *Development of the Electrical Recording Meters*, by Asst. Prof. M. B. Stout, University of Michigan. Slides. Large amount of interest shown in the discussion. Report on plans for annual outing on June 18, appointment of teller's committee, and discussion of committee appointments for next year. May 21. Attendance 150.

Annual Outing of the Section at Edison Boat Club. Officers for next year were announced as follows: Chairman, L. F. Hickernell; Vice-Chairman, LeRoy Braisted; Secretary-Treasurer, T. N. Lacy. June 18. Attendance 110.

Erie

Power Company Development and Industrial Progress, by T. F. Barton, District Engr., General Electric Co., New York, Vice-President J. L. Beaver gave talk on the work of the Institute. Officers for next year are as follows: Chairman, W. H. Pelton; Secretary, G. I. LeBaron; Executive Committee, W. H. Reynolds, M. V. Wright and H. B. Joyce. June 11. Attendance 80.

Niagara Frontier

Construction of the Cascade Tunnel on the Great Northern Railway, by J. B. Cox, Railway Engg. Dept., General Electric Co., Schenectady. Film—"Driving the Longest Railroad Tunnel in the Western Hemisphere." Reports of Membership Committee and Treasurer. The Chairman appointed an Auditing Committee. The proposed "Agreement for the joint use of club rooms, meeting rooms, secretarial services and other facilities of the Engineering Society of Buffalo, Inc., by the Niagara Frontier Section" was unanimously adopted. The Chairman turned over to the Membership Committee a list of enrolled Students in western New York, with the request that the committee get into personal touch with a view to securing their active participation. Election of officers as follows: Chairman, R. T. Henry; Secretary-Treasurer, E. P. Harder; Executive Committee, R. W. Graham, R. L. Kimber. George W. Eighmy, General Electric Co., Buffalo, was appointed Assistant Secretary by the Chairman. The speaker was entertained at a dinner preceding the meeting. May 24. Attendance 105.

Philadelphia

Illumination of the Mastbaum Theatre, by J. F. Costello, Frank Adam Electric Co., and

Ventilation, Mechanical Equipment and General Construction of the Mastbaum Theatre, by C. S. Dingleman, Consulting Engr. The papers were followed by an inspection of the electrical and mechanical equipment of the Mastbaum Theatre. Election of officers for next year as follows: Chairman, R. H. Silbert; Secretary, J. L. MacBurney; Treasurer, E. C. Drew. Joint meeting with Philadelphia Section, Illuminating Engineering Society, and Electric Club of Philadelphia. June 10. Attendance 465.

Spokane

Annual Dinner Meeting. Chairman Olsen gave a brief address regarding the activities of the past year. Reports of several committees presented. The following officers were elected for next year: Chairman, Earl Baughn; Vice-Chairman, James B. Fisken; Secretary, C. B. Carpenter; Executive Committee, W M. Allen, L. R. Gamble and H. L. Vincent. May 24. Attendance 15.

Lecture and Demonstration of modern electrical marvels and inventions pertaining to sound transmission, by S. P. Grace, Ass't Vice-President, Bell Telephone Laboratories, Inc. June 11. Attendance 1850.

A. I. E. E. Student Activities

PAST BRANCH MEETINGS

Brooklyn Polytechnic Institute

Business Meeting. Election of officers. May 24. Attendance 40.

University of Detroit

Annual Banquet. Speakers: N. S. Diamant, Research Engr., Chrysler Corp.; Dr. T. Leucutia, Radiological Dept., Harper Hospital; W. A. Furst, Mgr. Engineering Dept., Westinghouse Electric & Mfg. Co., Detroit. C. W. Hungerford, Advertising Mgr., Michigan Bell Telephone Co.; R. Foulfrod, Plant Extension Eng., Michigan Bell Telephone Co., and E. E. Walerych, Supt. of Maintenance, Plymouth Plant, Chrysler Corp. June 6. Attendance 100.

University of Idaho

Business Meeting. Election of officers. May 24. Attendance 30.

School of Engineering of Milwaukee

Copper, by Dr. Koch, Head of Chemistry Dept. Film—"From Mine to Consumer—The Story of Anaconda." Election of officers for next year as follows: Chairman, T. J. Coleman, Jr.; Vice-Chairman, W. L. Haegquist; Secretary, K. O. Werwath; Treasurer, C. H. Skinner. January 5. Attendance 46.

University of Minnesota

Business Meeting. Election of officers. May 24.

Student Work in A. I. E. E. Branches, by Prof. J. H. Kuhlmann, Counselor;

Relation of A. I. E. E. Branch to Department of Electrical Engineering, by Prof. J. M. Bryant, Head of Dept.;

Relation of A. I. E. E. Section to Branch Work, by Prof. M. E. Tood, Chairman, Minnesota Section, and

The Young Electrical Student and the A. I. E. E., by Prof. E. W. Johnson. Annual banquet, held largely to create more interest and enthusiasm in the work of the Branch, Prof. W. T. Ryan, toastmaster. May 29. Attendance 57.

University of Idaho

Business Meeting. May 7.

Pennsylvania State College

New York's City Subways, by Mr. Heine. Film—"Building New York's Newest Subway." Joint meeting with the Metallurgical Society. March 13. Attendance 26.

Life in Porto Rico, by Manual Andjuar. April 10. Attendance 20.

Jewelled Bearing Manufacture, by B. W. St. Clair, Head of the Standards Laboratory, Lynn Works, General Electric Co. Slides and specimens. President-elect W. Mason gave a report on the Cincinnati Regional Meeting. May 1. Attendance 30.

University of Wisconsin

Business Meeting. Election of officers. May 28. Attendance 23.

Engineering Societies Library

The Library is a cooperative activity of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers and the American Society of Mechanical Engineers. It is administered for these Founder Societies by the United Engineering Society, as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West Thirty-ninth St., New York.

In order to place the resources of the Library at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references to engineering subjects, copies or translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged.

The Director of the Library will gladly give information concerning charges for the various kinds of service to those interested. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

The library is open from 9 a. m. to 10 p. m. on all week days except holidays throughout the year except during July and August when the hours are 9 a. m. to 5 p. m.

BOOK NOTICES, JUNE 1-30, 1929

Unless otherwise specified, books in this list have been presented by the publishers. The Society does not assume responsibility for any statement made; these are taken from the preface or the text of the book.

All books listed may be consulted in the Engineering Societies Library.

ARC WELDING; Lincoln Prize Papers submitted to the American Society of Mechanical Engineers. Edited by Edward P. Hulse. N. Y., McGraw-Hill Book Co., 1929. 421 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

The Lincoln Arc Welding Prizes were given by the Lincoln Electric Company to be awarded by the American Society of Mechanical Engineers for the three best papers on arc welding. The seven papers published in this book include the three prize winners, the two that received honorable mention and two others of unusual merit.

The papers are "Arc Welding—Its Fundamentals and Economics" by James W. Owens, "Fundamental Principles of Arc Welding" by Prof. H. Dustin, "Electric Welding of Ships, Bulkheads and Similar Plated Structures" by Commander H. E. Russell. "Theory and Application of the Base Plate Arc Welded Rail Joint" by Frank B. Walker, "Stable Arc Welding on Long-Distance Pipe Lines" by B. K. Smith, "Arc Welding as Applied to Construction Work at the Philadelphia Navy Yard" by M. W. Kennedy and F. H. Wieland, and "Arc Welding of Duplicate Steel Structures" by W. H. Himes.

BASES OF MODERN SCIENCE.

By J. W. N. Sullivan. Garden City, N. Y., Doubleday, Doran & Co., 1929. 274 pp., 8 x 5 in., cloth. $2.00.

An admirable history of the growth and development of physical science from the time of Copernicus to the present day. Mathematical formulas are conspicuously absent, the treatment is as simple as the subject permits, and the book traces very satisfactorily the rise and decline of the conceptions which have dominated physics from time to time.

BERICHTE UBER BETRIEBSWISSENSCHAFTLICHE ARBEITEN, bd. 1 & bd. 2. Berlin, V. D. I. Verlag, 1929. 63 pp. & 51 pp., illus., diagrs., 12 x 9 in., paper. 11.-r. m. each.

The first two issues of a new serial devoted to the publication of complete reports of interesting investigations of processes and machinery which, for lack of space, cannot be given fully in ordinary periodicals. Each of these issues contains three reports from the laboratory of the Dresden Technical High School. The first, on woodworking machinery, treats of planing, mortising and working veneers. The second, on metal working processes, discusses the drawing of hollow vessels from thin sheets, the efficiency of machine hacksaws, and broaching.

BERICHTFOLGE DES KOHLENSTAUBAUSSCHUSSES DES REICHSKOHLENRATES, 18th & 19th, April & June 1929. Berlin, V. D. I. Verlag, 1929. 16 pp. & 12 pp., 12 x 8 in., paper. 1 r. m. each.

The papers in these two reports of the Committee on Pulverized Coal discuss various questions of interest to users; facts for buyers, ignition and combustion phenomena at various furnace pressures, heat flow and storage in furnace walls; the behavior of ash; the possibility of separating ash from flue gases; conveying pulverized coal; and the extinguishing of pulverized coal fires.

BUSINESS LAW FOR ENGINEERS.

By C. Frank Allen. 3rd edition. N. Y., McGraw-Hill Book Co., 1929. Various paging, 9 x 6 in., cloth. $4.00.

This text aims "to give the engineer a sufficient understanding of important fundamental features of law, so that he may have some idea of when or how to act himself and when to seek expert advice." The author has had experience both as an attorney and as a civil engineer.

In this edition there is a new chapter on "cost plus" contracts, and several new forms of contracts.

DIAGRAMME UND TABELLEN ZUR BERECHNUNG DER ABSORPTIONS-KÄLTEMASCHINEN.

By Fr. Merkel and Fr. Bosnjakovic. Berlin, Julius Springer, 1929. 43 pp., diagrs., tables, 11 x 8 in., paper. 12.-r. m.

The simple formulas and graphical tables, which the authors have prepared from recent investigations, simplify greatly the design of absorption refrigerating machines. The necessary data and tables are given here, with a description of their use.

ELECTRICAL TRANSMISSION AND DISTRIBUTION . . . v. 5-6; Substation Work, pt. 1 & pt. 2. Edited by R. O. Kapp. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., tables, 8 x 5 in., cloth. $1.75 each.

Volumes five and six of this treatise on transmission and distribution treat of substations. Transformer construction and operation; converting machinery; mercury vapor rectifiers; the design, layout, testing and operation of a-c. substations; and automatic substations are considered. Each section is the work of one or more English specialists. The work is intended as a practical guide for those engaged in transmission work as builders or operators of transmission systems.

ELECTRICAL TRANSMISSION AND DISTRIBUTION, v. 7-8; v. 7, Instruments and Meters. v. 8, Auxiliary Plant. Edited by R. O. Kapp. N. Y., Isaac Pitman & Sons, 1929. 2 v., illus., diagrs., 8 x 5 in., cloth. $1.75 each.

These two volumes complete the work. Volume 7 contains data on ammeters, voltmeters, ohmmeters, wattmeters, instrument transformers, electricity meters, the operation of meter departments, and control room design. Volume 8 discusses boosting devices and the power-factor problem, and contains an appendix on the development of the high-tension circuit breaker which describes recent research work on the breaker and the breaker arc.

ELECTRIFICATION OF STEAM RAILROADS.

By Kent Tenney Healy. N. Y., McGraw-Hill Book Co., 1929. 395 pp., illus., diagrs., tables, 9 x 6 in., cloth. $5.00.

Combines a description of the physical characteristics of the elements of electrification with an analysis of economic problems and the operating performance of both electrification and electric operation. Power contracts, overhead systems of distribution and the economics of electrification are given special attention.

ENGLISH AND SCIENCE.

By Philip B. McDonald. N. Y., D. Van Nostrand Co., 1929. 192 pp., 9 x 6 in., cloth. $2.00.

Proper forms for formal and informal reports and for letters, the importance of correct language, common faults of poor writers, punctuation, and sentence structure are the subjects to which Professor McDonald devotes the greater part of his textbook. In addition there is much sound advice on minor matters, and interesting suggestions for cultural reading. The book should be helpful in assisting professional men to attain a concise, attractive, clear style.

DIE FESTIGKEIT DER SCHRAUBENVERBINDUNG IN ABHÄNGIGKEIT VON DER GEWINDETOLERANZ, IM AUFTRAGE VON BAUER U. SCHAURTE . . .edited by Kurt Mütze.

Berlin, Julius Springer, 1929. 108 pp., illus., plates, diagrs., tables, 9 x 6 in., cloth. 6,50 r. m.

This investigation of the factors that influence the strength of bolts was carried out at the Dresden Technical High School, at the request of leading German bolt makers. The methods and instruments are described in full, as well as the results obtained.

FESTSCHRIFT DER TECHNISCHEN HOCHSCHULE. Stuttgart . . . 1829-1929. Berlin, Julius Springer, 1929. 475 pp., illus., diagrs., 11 x 8 in., cloth. 24.-r. m.

This attractive volume is issued by the Stuttgart Technical High School in celebration of its centennial. Thirty-seven papers by members of the faculty describe investigations in the various fields—engineering, science and art—in which the school is active.

GENAUIGKEITSERMITTLUNGEN AN WERKSTÜCKEN ZUR BESTIMMUNG ZWECKMASSIGER PASSUNGSSITZE.

By K. Gramenz. Berlin, V. D. I. Verlag, 1929. 24 pp., illus., diagrs., 12 x 9 in., paper. 3-r. m.

The effectiveness and adaptability to shop practise of the system of fits and tolerances adopted by a factory is the subject under investigation here. The pamphlet describes methods and apparatus for determining the quality of workmanship existing in a factory, and for ascertaining the most economical degree of exactitude to be sought.

DIE GRUNDLAGEN DER TRAGFLÜGEL—UND LUFTSCHRAUBENTHEORIE.

By H. Glauert. Trans. by H. Holl. Berlin, Julius Springer, 1929. 202 pp., diagrs., tables, 9 x 6 in., paper. 12,75 r. m.

A translation of "The Elements of Aerofoil and Airscrew Theory," with practically no changes from the English edition of 1926. The book presents the theory in a form suitable for students who do not know hydrodynamics, and avoids complex mathematical analysis.

JUNKERS; FESTSCHRIFT.

By A. Berson and others. Issued by Verein Deutscher Ingenieure. Berlin, V. D. I. Verlag, 1929. 99 pp., illus., 12 x 9 in., cloth. 6,-r. m.

This attractive volume, prepared to celebrate the seventieth birthday of Hugo Junkers, is a review of the outstanding events of his engineering career by some of his friends. The Junkers oil engine, Junkers' contributions to heat engineering, construction and materials, and his activities in aviation are described by various specialists.

MANUAL OF ENGINEERING DRAWING.

By Thomas E. French. 4th edition. N. Y., McGraw-Hill Book Co., 1929. 466 pp., illus., diagrs., tables, 9 x 6 in., cloth. $3.00.

The fourth edition of this popular text has been made to conform to the standards of the American Standards Association, and certain topics, including auxiliary projections, dimensioning, and gears, have been expended. The number of problems has also been increased. The book aims to provide a thorough course based on good engineering practise.

MECHANICS FOR ENGINEERS.

By Leroy W. Clark. Baltimore, Williams & Wilkins, 1928. 192 pp., diagrs., 9 x 6 in., cloth. $3.50.

Simplicity and brevity are emphasized in this textbook based on the author's courses at the Rensselaer Polytechnic Institute. The book aims to give a knowledge of mechanics adequate for the needs of undergraduate students in a very short amount of time, and to provide the necessary foundation for advanced work by graduate students.

MEN, MONEY AND MOTORS.

By Theodore F. MacManus and Norman Beasley. N. Y., Harper & Brothers, 1929. 284 pp., 9 x 6 in., cloth. $3.00.

This is the personal story of the pioneers of the automobile industry. Their early struggles, their failures and successes, are told graphically. It tells how the industry began, how the various companies grew and were consolidated into the present corporations, and of the personal fortunes of the leaders in developing them. An interesting story is told dramatically.

PASTURES OF WONDER; the Realm of Mathematics and the Realm of Science.

By Cassius Jackson Keyser. N. Y., Columbia University Press, 1929. 208 pp., 8 x 6 in., bound. $2.75.

Professor Keyser's book has a two-fold purpose. He first endeavors to help the intelligent layman to acquire an understanding of the modern meaning of the term Mathematics. In the second part of his book, which discusses the meaning of the term Science, he proposes a definition of Science which will, he believes, remove the ambiguity now associated with the word.

Pitman's Technical Dictionary of Engineering and Industrial Science in Seven Languages; English, French, Spanish, Italian, Portugese, Russian and German, vol.1. Compiled by Ernest Slater. N. Y., Isaac Pitman & Sons, 1928. [3v. completed.] v. 1, 582 pp., 10 x 7 in., cloth. $12.50 a vol.

This dictionary will be found invaluable by every translator of English catalogs and technical articles and books into the languages that it covers. Unusual care seems to have been taken to cover the field adequately and to provide accurate equivalents. Special attention has been given to idiomatic phrases, and a useful essay on the art of technical translation is included.

Practical Primary Cells.

By A. Mortimer Codd. N. Y., Isaac Pitman & Sons, 1929. 127 pp., illus., diagrs., tables, 8 x 5 in., cloth. $1.50.

Gives working details for the primary cells that have the greatest practical value for laboratory and commercial uses. A list of some two hundred types of cells is included, showing their composition, inventor, and electromotive force.

Problemes de Statique Graphique et de Résistance des Matériaux.

By Louis Roy. Paris, Gauthier-Villars et Co., 1929. 119 pp., diagrs., 9 x 6 in., paper. 30 fr.

A collection of problems derived from examinations at the Institute of Electrical Engineering and Applied Mechanics at Toulouse University and those for certificates in applied mechanics. Intended as a companion to the author's textbook on the same subjects, and similarly arranged.

Radio Telegraphy and Telephony.

By Rudolph L. Duncan and Charles E. Drew. N. Y., John Wiley & Sons, 1929. 950 pp., illus., diagrs., tables, 9 x 6 in., cloth. $7.50.

A systematic presentation of the subject in great detail, covering generating and receiving apparatus of all kinds, and discussing both theoretical and practical aspects of radio communication. The authors are experienced teachers, connected with the Radio Institute of America. The book is designed for use as a textbook and work of reference.

Railway Electrification and Traffic Problems.

By Philip Burtt. N. Y., Isaac Pitman & Sons, 1929. 197 pp., illus., maps, 9 x 6 in., cloth. $3.00.

A presentation of the general question of electrification from the point of view of a traffic manager. It brings together the pertinent facts from the experience of various countries and discusses the problems involved. The author is an advocate of electrification for main lines.

Taschenbuch für Berg—und Hüttenleute.

Edited by F. Kögler. 2d edition. Berlin, Wilhelm Ernst & Sohn, 1929. 1207 pp., diagrs., tables, 7 x 5 in., cloth. 33,50 r. m.

This reference book brings together a remarkable amount of the practical data ordinarily needed by the mining engineer and metallurgist. The new edition has been carefully revised and considerably enlarged.

Das Technikerproblem.

By W. Franz. Berlin, V. D. I. Verlag, 1929. 49 pp., 8 x 6 in., paper. 2,50 r. m.

A discussion of engineering education, particularly of the proper curriculum for training engineers for state and municipal offices. The author outlines courses which include both economic and engineering subjects, corresponding somewhat to the courses in engineering administration offered by some American colleges.

Telephone and Power Transmission.

By R. Bradfield and W. J. John. N. Y., John Wiley & Sons, 1929. 238 pp., diagrs., tables, 9 x 6 in., cloth. $5.75.

A textbook intended for those who approach the subject with a limited knowledge of mathematics. The authors first give an introductory statement on the use of vectors and hyperbolic functions, after which the theory of transmission is presented. The practical application of the theory to the problems of long-distance telephone transmission is then shown, after which the problems of single-phase and three-phase power lines are discussed.

Textbook of Illumination.

By William Kunerth. N. Y., John Wiley & Sons, 1929. 269 pp., diagrs., 9 x 6 in., cloth. $3.00.

A brief text based on the course given by the author to senior electrical students at the Iowa State College. The principles are presented, with enough applications to illustrate them, but without any effort to present all possible forms. The course is thought sufficient to prepare the student for the problems that arise in ordinary practise.

Treatise on Differential Equations.

By A. R. Forsyth. 6th edition. N. Y. & Lond., Macmillan Co., 1929. 583 pp., 9 x 6 in., cloth. $6.75.

Professor Forsyth's well-known volume is intended as a practical working text-book on the subject, and the general theory has been definitely avoided.

The sixth edition varies from the fourth in minor matters only.

Engineering Societies Employment Service

Under joint management of the national societies of Civil, Mining, Mechanical and Electrical Engineers cooperating with the Western Society of Engineers. The service is available only to their membership, and is maintained as a cooperative bureau by contribution from the societies and their individual members who are directly benefited.

Offices:—31 West 39th St., New York, N. Y.,—W V. Brown, Manager.
1216 Engineering Bldg., 205 W. Wacker Drive, Chicago, Ill., A. K. Krauser, Manager.
57 Post St., San Francisco, Calif., N. D. Cook, Manager.

MEN AVAILABLE.—Brief announcements will be published without charge but will not be repeated except upon requests received after an interval of one month. Names and records will remain in the active files of the bureau for a period of three months and are renewable upon request. Notices for this Department should be addressed to ***EMPLOYMENT SERVICE, 31 WEST 39th Street, New York City,*** *and should be received prior to the 15th day of of the month.*

OPPORTUNITIES.—A Bulletin of engineering positions available is published weekly and is available to members of the Societies concerned at a subscription of $3 per quarter, or $10 per annum, payable in advance. Positions not filled promptly as a result of publication in the Bulletin may be announced herein, as formerly.

VOLUNTARY CONTRIBUTIONS.—Members obtaining positions through the medium of this service are invited to cooperate with the Societies in the financing of the work by contributions made within thirty days after placement, on the basis of one and one-half per cent of the first year's salary: temporary positions (of one month or less) three per cent of total salary received. The income contributed by the members, together with the finances appropriated by the four societies named above will it is hoped, be sufficient not only to maintain, but to increase and extend the service.

REPLIES TO ANNOUNCEMENTS.—Replies to announcements published herein or in the Bulletin, should be addressed to the key number indicated in each case, with a two cent stamp attached for reforwarding, and forwarded to the Employment Service as above. Replies received by the bureau after the positions to which they refer have been filled will not be forwarded. **See also p. 42 of Advertising Section**

POSITIONS OPEN

ELECTRICAL ENGINEER, about 35, with practical experience in general manufacturing of transformers, motors, switchgear; able to diagnose trouble in repairing of apparatus, full knowledge of mechanical tools and winding necessary. All round man required to take charge of plants. Apply by letter stating full details with references and salary expected. Opportunity. Location, Western Canada. X-8608-CS.

MEN AVAILABLE

ELECTRICAL ENGINEER, age 31; married; fourteen years direct experience with the design, construction and erection of electrical equipment; also experienced in the design and layout of substations, transmission lines, etc. Desires position with reliable electrical concern who would be able to utilize his services. Canada preferred. C-6149.

ELECTRICAL ENGINEER, 37, married. Nine years' experience with stations, branch of large municipal plant design, estimates, appraisals of large a-c. and d-c. equipment, mechanical, communication work. Good technical,

business training, sales ability. Desires position involving business as much as technical work, with growing concern, good future essential. Now employed; available at short notice. Location, Canada. C-6165.

ELECTRICAL AND MECHANICAL ENGINEER, 31, graduate, seven years' experience with public utility, steel mill, and manufacture; desires new connection in executive capacity involving major responsibilities and requiring alertness, initiative, personality, resourcefulness, and dependability. Thoroughly familiar with both the electrical and steam ends. At present in charge of responsible work. C-1297.

ELECTRICAL–MECHANICAL ENGINEER, 32 years old; 6½ years testing, designing, transmission line research and central station experience, desires position of responsibility with manufacturing or operating company. C-200.

PUBLIC UTILITY OPERATION AND MANAGEMENT, Electrical Engineer with broad experience in public utility design and operation, and in accident prevention applied to public utility design and operation. Experience in investigation and report work. Knowledge of personnel studies. Preferred location, Eastern United States. B-4411.

GRADUATE ELECTRICAL AND MECHANICAL ENGINEER, with two years post graduate work physics. Desires position as research or consulting engineer, 10 years' experience high-tension and automatic devices. Some X-ray work. Will accept position as designing engineer where facilities for research are available. Executive, organizing ability. Location, United States, or abroad. B-9406.

ELECTRICAL ENGINEER, over 20 years' experience, including two years as associate physicist at Bureau of Standards. Last four years full professor of Electrical Engineering in leading technical school. Specialist in theoretical and mathematical analysis of engineering problems; research, design and invention. Broad knowledge of radio. Location preferred South or East. C-6141.

DEVELOPMENT ENGINEER, 15 years' experience with engineering developments. Can take entire charge of a development program. B-208.

ELECTRICAL ENGINEER, year's experience both in hydro and steam in construction and operating. Member A. I. E. E.; married; college education, speaks Spanish, employed in Latin countries for over seven years. Present employed would be available in 30 days. Foreign fields preferred. B-4552.

PIONEER, on a-c. network design; technical graduate with 14 years' experience in the design, construction and operation of public utility properties; desires to make connection with a public utility company or a contracting firm with a view to future partnership. A-4319.

ELECTRICAL ENGINEER. Technically trained, mature judgment, personality, 11 years' experience, large industrial plants such as steel, paper mills; construction, maintenance, repairs, redesigning, rewinding armatures, stators, transformers; design, construction special automatic controls for specific duty. Four years' experience, large custom repair shop. Desires position industrial concern, custom repair shop. Middle West preferred. C-5916.

ELECTRICAL ENGINEER, graduate, desires position with manufacturing concern public utility or contractor, 18 years' experience in the electrical industry, 10 of which, to date, connected with the largest public utility company. Design, construction, maintenance, power houses, substations, distribution, handling materials, specifications, etc. Location, here or abroad. C-6055.

ELECTRICAL ENGINEER, B. S. 1921, one year as inspector and assistant research engineer on cables, seven years electrical designer of substations, power house, oil and copper refineries. Desires position in New York City, or Newark, New Jersey. C-5473.

ASSISTANT EXECUTIVE, 37, married, technically trained. Connections with large public utility, manufacturers and industrial consultants on work of administrative and commercial research nature. Especially qualified as assistant to busy executive needing man with management ability. Well endorsed. Prefers East. B-9122.

ELECTRICAL ENGINEER, having several years' practical experience and executive ability, winding, test and operation of a-c. and d-c. motors, generators; design, controllers, contactors, motors and electrical maintenance in industrial plants and steel mills. C-4128.

INVENTOR, Engineer will originate devices for specific requirements, develop for production. Expert knowledge of patents. Salary basis or otherwise. B-208.

PRODUCTION ENGINEER, 29, single, well trained in electrical and mechanical engineering. Desires permanent connection. Three years before graduation and four years after graduation of diversified engineering experience. Location, anywhere. C-696.

MEMBERSHIP—Applications, Elections, Transfers, Etc.

APPLICATIONS FOR ELECTION

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before August 31, 1929.

Bullen, R. P., General Electric Co., Worcester, Mass.
Coleman, E. S., Dallas Power & Light Co., Dallas, Tex.
Collins, W. G., Pacific Tel. & Tel. Co., San Francisco, Calif.
Cox, A. A., c/o General Electric Co., New York, N. Y.
de Ferranti, M. A., General Electric Co., Schenectady, N. Y.
Early, F. J., Jr., P. J. Walker Co., San Francisco, Calif.
Faige, M. D., R. C. A. Photophone Inc., New York, N. Y.
Fyfe, L. J. G., Thames Valley Electric Power Board, Te Aroha, Auckland, N. Z.
Gallagher, G. J., Continental-Diamond Fibre Co., Boston, Mass.
Hamby, H. M., Stone & Webster Engg. Corp., Bennings, D. C.
Janes, G. N., Associated Gas & Electric Co., Calais, Me.
Jessop, G. A., (Member), S. Morgan Smith Co., York, Pa.
Kilgore, L. A., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Lott, H. A., Southern California Edison Co., Los Angeles, Calif.
Mapes, L. R., (Member), Illinois Bell Telephone Co., Chicago, Ill.
Meagher, R. J., Rochester Gas & Electric Corp., Rochester, N. Y.
Mulligan, J. E., Mass. Institute of Technology, Cambridge, Mass.
Murray, V. M., School of Engineering of Milwaukee, Milwaukee, Wis.
O'Neil, C. B., Fairbanks, Morse & Co., Houston, Tex.
Prutton, L. J., Cleveland Electric Illuminating Co., Cleveland, Ohio
Schoenborn, F. J. W. F., Radio Corp. of America, Riverhead, N. Y.
Scholten, C. H., Aluminum Good Mfg. Co., Manitowoc, Wis.
Smith, C. J., General Electric Co., Cincinnati, Ohio
Sperry, E. A., Jr., (Member), Sperry Gyroscope Co., Brooklyn, N. Y.
Storms, H. J., Western Union Telegraph Co., Spokane, Wash.
Stratford-Handcock, A. G., Plastow Electric, New Westminster, B. C., Can.
Thomas, C. A., Fairbanks Morse & Co., Indianapolis, Ind.
Thoren, A. W., Westinghouse Elec. & Mfg. Co., New York, N. Y.
Whiteley, H. O., Western Electric Co., Chicago, Ill.
Wiley, W. S., Cia. Cubana de Electricidad, Havana, Cuba
Wilhelm, G. R., Chespeaker & Potomac Telephone Co., Washington, D. C.
Wilson, R. C., The Philip Carey Mfg. Co., Cincinnati, Ohio
Wolfe, R. L., Robbins & Myers, Inc., Springfield, Ohio
Total 27.

Foreign

Abigail, E. W., Shanghai Municipal Council, Shanghai, China
Banaji, P. K., (Fellow), Municipal Council, Tanjore, India
Eckmann, H. H., Chile Telephone Co., Santiago, Chile, So. America
James, J. C., P. O. Box 11, Wanganui, N. Z.
Kripalani, M. T., G. I. P. Railway, Matunga, Bombay, India
Renaud, C., Ateliers de Constructions Electriques de Charleroi, Charleroi, Belgium
Total 6.

OFFICERS A. I. E. E. 1929-1930

President
HAROLD B. SMITH

Junior Past Presidents
R. F. SCHUCHARDT
BANCROFT GHERARDI

Vice-Presidents
E. B. MERRIAM
H. A. KIDDER
W. T. RYAN
B. D. HULL
G. E. QUINAN
HERBERT S. EVANS
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J. E. KEARNS
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National Treasurer
GEORGE A. HAMILTON

National Secretary
F. L. HUTCHINSON

Honorary Secretary
RALPH W. POPE

A. I. E. E. COMMITTEES AND REPRESENTATIVES

The list of committees and representatives is omitted from this issue, as new appointments are being made for the administrative year beginning August 1; and these will be listed in the September issue.

LIST OF SECTIONS

Akron
Atlanta
Baltimore
Birmingham
Boston
Chicago
Cincinnati
Cleveland
Columbus
Connecticut
Dallas
Denver
Detroit-Ann Arbor
Erie
Fort Wayne
Houston
Indianapolis-Laf.
Ithaca
Kansas City
Lehigh Valley
Los Angeles
Louisville
Lynn
Madison
Mexico
Milwaukee
Minnesota
Nebraska
New York
Niagara Frontier
North Carolina
Oklahoma
Panama
Philadelphia
Pittsburgh
Pittsfield
Portland, Ore.
Providence
Rochester
St. Louis
San Francisco
Saskatchewan
Schenectady
Seattle
Sharon
Southern Virginia
Spokane
Springfield, Mass.
Syracuse
Toledo
Toronto
Urbana
Utah
Vancouver
Washington
Worcester
Total 56.

LIST OF BRANCHES

Akron, Municipal University of, Akron, Ohio
Alabama Polytechnic Institute, Auburn, Ala.
Alabama, University of University, Ala.
Arizona, University of, Tucson, Ariz.
Arkansas, University of, Fayetteville. Ark.
Armour Institute of Technology, 3300 So. Federal St., Chicago. Ill.
Brooklyn Polytechnic Institute, 99 Livingston St., Brooklyn, N. Y.
Bucknell University, Lewisburg, Pa.
California Institute of Technology, Pasadena. Calif.
California, University of, Berkeley, Calif.
Carnegie Institute of Technology, Pittsburgh, Pa.
Case School of Applied Science, Cleveland, Ohio.
Catholic University of America, Washington, D. C.
Cincinnati, University of, Cincinnati, Ohio.
Clarkson College of Technology, Potsdam, N. Y.
Clemson Agricultural College, Clemson College, S. C.
Colorado State Agricultural College, Fort Collins, Colo.
Colorado, University of, Boulder, Colo.
Cooper Union, New York, N. Y.
Cornell University, Ithaca, N. Y.
Denver, University of, Denver, Colo.
Detroit, University of, Detroit, Mich.
Drexel Institute, Philadelphia, Pa.
Duke University, Durham, N. C.
Florida, University of, Gainesville, Fla.
Georgia School of Technology, Atlanta, Ga.
Idaho, University of, Moscow Idaho.
Iowa State College, Ames, Iowa.
Iowa, State University of, Iowa City, Iowa.
Kansas State College, Manhattan, Kansas.
Kansas, University of, Lawrence, Kans.
Kentucky, University of, Lexington, Ky.
Lafayette College, Easton, Pa.
Lehigh University. Bethlehem, Pa.
Lewis Institute, Chicago, Ill.
Louisiana State University Baton Rouge, La
Louisville, University of, Louisville, Ky.
Maine, University of, Orono, Maine.
Marquette University, 1200 Sycamore St., Milwaukee, Wis.
Massachusetts Institute of Technology, Cambridge, Mass.
Michigan State College, East Lansing, Mich.
Michigan, University of, Ann Arbor, Mich.
Milwaukee, School of Engineering of, 163 East Wells St., Milwaukee, Wis.
Minnesota, University of, Minneapolis, Minn.
Mississippi Agricultural & Mechanical College, A. & M. College, Miss.
Missouri School of Mines & Minetallurgy, Rolla, Mo.
Missouri, University of, Columbia, Mo.
Montana State College, Bozeman, Mont.
Nebraska, University of, Lincoln, Neb.
Nevada, University of, Reno, Nevada.
Newark College of Engineering, 367 High St., Newark, New Jersey.
New Hampshire, University of, Durham, N. H.
New York, College of the City of, 139th St., & Convent Ave., New York, N. Y.
New York University, University Heights, New York, N. Y.
North Carolina State College, Raleigh, N. C.
North Carolina, University of, Chapel Hill, N. C.
North Dakota Agricultural College, State College Station, Fargo, N. D.
North Dakota, University of, University Station, Grand Forks, N. D.
Northeastern University, 316 Huntington Ave., Boston 17, Mass.
Notre Dame, University of, Notre Dame, Ind.
Ohio Northern University, Ada, Ohio.
Ohio State University, Columbus, O.
Ohio University, Athens, O.
Oklahoma A. & M. College, Stillwater, Okla.
Oklahoma, University of, Norman, Okla.
Oregon State College, Corvallis. Ore.
Pennsylvania State College, State College, Pa.
Pennsylvania, University of, Philadelphia, Pa.
Pittsburgh, University of, Pittsburgh, Pa.
Princeton University, Princeton, N. J.
Purdue University, Lafayette, Indiana.
Rensselaer Polytechnic Institute, Troy, N. Y.
Rhode Island State College, Kingston, R. I.
Rose Polytechnic Institute, Terre Haute, Ind.
Rutgers University, New Brunswick, N. J.
Santa Clara, University of, Santa Clara, Calif.
South Carolina, University of, Columbia, S. C.
South Dakota State School of Mines, Rapid City, S. D.
South Dakota, University of, Vermillion, S. D.
Southern California, University of, Los Angeles, Calif.
Stanford University, Stanford University, Calif.
Stevens Institute of Technology, Hoboken, N. J.
Swarthmore College, Swarthmore, Pa.
Syracuse University, Syracuse, N. Y.
Tennessee, University of, Knoxville, Tenn.
Texas, A. & M. College of, College Station, Texas.
Texas, University of, Austin, Texas.
Utah, University of, Salt Lake City, Utah.
Vermont, University of, Burlington, Vt.
Virginia Military Institute, Lexington, Va.
Virginia Polytechnic Institute, Blacksburg, Va.
Virginia, University of, University, Va.
Washington, State College of, Pullman, Wash.
Washington University, St. Louis, Mo.
Washington, University of, Seattle, Wash.
Washington and Lee University, Lexington, Va.
West Virginia University, Morgantown, W. Va.
Wisconsin, University of, Madison, Wis
Worcester Polytechnic Institute, Worcester, Mass.
Wyoming, University of, Laramie, Wyoming.
Yale University, New Haven, Conn.
Total 101

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Circuit Breakers.—Bulletin GEA-720A, 16 pp. Describes G-E high-speed circuit breakers, built in standard designs ranging from 600 to 3000 volts and in current capacities from 625 to 4000 amperes. General Electric Company, Schenectady, N. Y.

Connectors.—Bulletin 38-CC, 8 pp. Describes Sumpter compression type connectors for wire connections. No bolts are used with these connectors. Delta-Star Electric Co., 2400 Block, Fulton Street, Chicago.

Armorclad Switchgear.—Bulletin 1145, 28 pp. Describes Allis-Chalmers, Reyrolle armorclad, oil circuit-breaker equipment for power stations, substations and general industrial purposes. Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

Air-Break Switch Controls.—Bulletin 24, 8 pp. Describes Pacific Electric motor controls for the operation of group controlled air-break switches up to and including 73 kv. rating. Pacific Electric Manufacturing Corp., 5815 Third St., San Francisco, Cal.

Outdoor Switching Equipment.—Bulletin GEA-1123, 12 pp. Describes G-E fusible cutouts and current-limiting resistors. Bulletin GEA-1113, 20 pp. Describes connectors and fittings for outdoor switching equipment. Ceneral Electric Company, Schenectady, N. Y.

Amperehour Meters.—Bulletin 78, 16 pp. Describes Sangamo type "N" amperehour meters. These instruments are extensively used in storage battery installations to indicate the state of charge of the battery and to terminate the charge automatically when the battery is full. Sangamo Electric Company, Springfield, Ill.

NOTES OF THE INDUSTRY

Increased Orders for General Electric Company.—According to an announcement by President Gerard Swope, orders received by the General Electric Company for the three months ending June 30, amounted to $119,351,248 compared with $90,431,957 for the corresponding quarter for 1928, an increase of 32 per cent. For the six months ending June 30, orders received amounted to $220,716,456, compared with $170,357,797 for the first six months of last year, an increase of 30 per cent.

Large Westinghouse Orders.—The Westinghouse Electric & Manufacturing Company has received an order from the Youngstown Sheet & Tube Company for apparatus amonting to more than one-half million dollars. This equipment covers the motors and control for use in driving a 10″ and 14″-18″ merchant mill to be installed in the Indiana Harbor Works of the company. Another contract, recently received from the West Leechburg Steel Company, covers the complete electric drive for a new 12″ hot strip mill, to replace an old Belgian type mill.

Record Transformer by Ferranti, Ltd.—It is reported that Ferranti, Ltd., are constructing at their plant in Hollinwood, England, the largest three-phase transformer yet built. The specifications call for 132,000-volt capacity and 80,000 kw. rating. According to the announcement, the largest transformer of this type in use today has a rating of 75,000 kv-a., and this was also built by Ferranti, Ltd. The machine now under construction is the fourth of a series to be built by Ferranti, Ltd. for the British National Electricity Scheme.

Buildings by the Austin Company for the Electrical Industry.—The Pacific States Electric Co., Pacific Coast sales organization of the General Electric Co., will establish a fully-equipped sales office and warehouse in a new $125,000 reinforced concrete structure at Seattle. The warehouse is being built by the Austin Company of Cleveland, industrial architects and builders, and calls for completion in 100 working days. The Lincoln Electric Company, Cleveland, has also awarded a contract to the Austin Company for the design and construction of an all-welded warehouse for steel storage, to cost $65,000, at the Lincoln plant in Cleveland, and scheduled for completion early in September.

The Bull Dog Electric Products Company, Detroit, Michigan, has announced the following policy in relation to the manufacture of their products:

"Effective at once, we as leading manufacturers of products for electrical distribution and control shall discontinue advertising, offering for sale and manufacturing all live-face electric products not recognized and approved by the safety recommendations and rules as published by the Department of Commerce, U. S. Bureau of Standards, in accordance with the procedure of the American Engineering Standards Committee. In line with this policy, we will no longer manufacture the following: (1) Live face or open type lighting panelboards. (2) Lighting panelboards having main fuses (not switched) or fusible only subfeeds on the panels. (3) Feeder or distributing panelboards having fuses only in the branches (not switched). As heretofore, we shall continue to devote our entire energies and resources to the increased use of electricity through promotion of safety electrical products for the protection of life and property."

Enduring Insulation on Old Wire.—Insulation that has stood the test of time for thirty-six years, and that, today, possesses far greater insulating value than new code wire was brought to light recently, when the Holy Name Roman Catholic Cathedral in Chicago underwent alterations. This wire, which was installed by the Okonite Company of Passaic, New Jersey, in 1893, was given the most strenuous of physical and dielectric tests and was found to have the same breakdown qualities as new wire. The tinning on the copper conductor is bright in appearance and entirely free from corrosion. Specimens of the wire, which have no braids or other covering over the rubber insulation, were subject to a severe bending test and the insulation withstood this without cracking or checking. Dielectric strength was determined on three foot samples in water. The results obtained were equal to breakdown qualities shown by new wire of this size and wall thickness of insulation. Physical tests were made on specimens of the insulation removed from the conductor. The insulation adhered so firmly to the conductor that it was found necessary to use mercury to aid in obtaining undamaged test specimens. When it is considered that the insulation has been exposed to light and air for more than a third of a century without any protective covering, the outcome of these tests is made doubly remarkable.